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1.0 EXECUTIVE SUMMARY

The Bayer MaterialScience LLC (Bayer) New Martinsville manufacturing facility encompasses approximately 194 acres located along the eastern bank of the Ohio River, approximately 30 miles south of Wheeling, West Virginia, and 5 miles north of New Martinsville, West Virginia (Site). The Site is bounded by the Ohio River to the west, a steep wooded hillside to the east, the PPG Natrium Plant to the north, and the small community of Proctor, WV to the south (See **Figures 2-1 and 2-2)**.

The Site was first developed in 1954 to produce polyester resin. The Site location was selected to be adjacent to the PPG Industries plant immediately to the north because PPG could safely supply via pipeline the large quantities of chlorine needed for plant operations. Today, the Site is a vibrant industrial facility employing more than 600 people and infusing more than $130 Million into the region's economy through payroll, taxes and local purchases. Products from the plant are shipped by truck and rail all over the country. The nearly 1 billion pounds of materials made annually are used in myriad consumer products such as automobiles, furniture, home construction, toys, shoes, sports equipment and many other applications from food preparation to steel manufacturing. Products produced include chemical intermediates, polyurethane materials, food grade hydrochloric acid, and iron oxide pigments.

The Site came under RCRA Corrective Action when that program was mandated by the Hazardous and Solid Waste Management Amendments of 1984 (HSWA) (HSWA Permit No. WVD 056 866 312). In HSWA, Congress directed EPA to require "corrective action for all releases of hazardous constituents from any solid waste management unit[1]…" [HSWA3004(u)]. This CMS has been developed consistent with the Resource Conservation and Recovery Act (RCRA) statute (as amended) and the RCRA regulation found in 40 CFR Part 264, Subpart S, "Corrective Action for Releases From Solid Waste Management Units at Hazardous Waste Management Facilities; Proposed Rule, "July 27, 1990 Federal Register (55 FR 30798); May 1, 1996 (61 FR 19432: November 30, 1998 (63 FR 65874); (68 FR 8757); and various policy and guidance documents that EPA has issued since the 1990 Subpart S proposal.

A significant historical event unrelated to Site operations but materially affecting environmental conditions and corrective actions at the Site today was the construction of the Hannibal Locks and Dam on the Ohio River directly across from the town of New Martinsville, WV by the US Army Corps of Engineers. The work was initiated in 1967 and completed in 1975. The installation of the lock and dam increased the upstream normal pool in that area of the Ohio River by approximately 20-feet. This had the effect of increasing the normal level of the groundwater saturated zone across the Site by approximately 20-feet as well. The most significant environmental effect of this rise in the water table at the Site was the saturation of the

[1] Solid waste management units or SWMUs were defined as areas within a site, identified by various means, as potential sources of soil and groundwater contamination.

previously unsaturated lower twenty feet (+/-) of waste in the South Landfill (SWMU 1), which began operation in 1955. This increase in the Site water table created the situation where the previously placed wastes in the landfill are now in the saturated zone and therefore in contact with groundwater.

Several investigations of the Site have been conducted over the past 25 years. A Description of Current Conditions (DOCC) Report prepared in 1997 pursuant to the RCRA Corrective Action process summarized key findings of those previous investigations to serve as a baseline for subsequent data gathering and analysis during the RCRA Facility Investigation (RFI) to follow. The DOCC summarized all available information regarding all of the Solid Waste Management Units (SWMUs) previously identified and justified their inclusion in, or exclusion from the RFI. The DOCC identified thirty (30) SWMUs to be included in the RFI.

The RFI was conducted in three phases between 1995 and 2001. The report on the third and final phase of the RFI was submitted December 2001 and approved by EPA on October 13, 2004. The RFI focused on evaluating the thirty (30) SWMUs and collecting data to support the next phase in the RCRA Corrective Action process, a Site Corrective Measures Study (CMS), the subject of this report.

The RFI determined that there were no unacceptable risks associated with the direct exposure pathway for any of the thirty (30) SWMUs and that no-further action was needed to address that potential exposure pathway. The RFI further concluded that sixteen (16) of the thirty (30) SWMUs were to be evaluated in the CMS for site-wide groundwater, pursuant to each SWMUs potential to leach constituents of interest (COIs) to groundwater at potentially unacceptable concentrations.

Lead responsibility for Agency oversight of the RCRA Corrective Action process at the Site began to transition following completion of the RFI in October, 2004. In 2004, the WVDEP received EPA authorization to carry out the RCRA Corrective Action Program statewide. The Bayer Site is one of thirty-three (33) RCRA Corrective Action facilities within West Virginia. The WVDEP decided that initially, the WVDEP Division of Waste Management (DWM) would transitionally assume responsibility for Corrective Action oversight at ten (10) of the thirty three (33) facilities in the state. The Bayer Site was among those 10 selected for the initial transfer. The DWM is currently the lead oversight Agency for the Site with EPA involvement continuing.

The CMS entails identification and evaluation of Corrective Measures alternatives for the Site and recommends a best-balanced Corrective Measures alternative. Preliminary to conductance of the CMS, the Corrective Action Objectives (CAOs) to be attained by the Corrective Measures to be identified in the CMS were defined and approved by the Agencies. In summary, the long-term CAOs for the Site are:

- Prevention of unacceptable human exposure to contaminated soils at all levels, with "unacceptable exposure" defined as carcinogenic risks > $1X10^{-6}$ and a Hazard Index for non-carcinogenic risks of > 1;
- Prevention of unacceptable human exposure to contaminated groundwater on-site and off-site with "unacceptable exposure" defined as above;
- Control of the migration of contaminated groundwater to a level that is protective of surface water quality, with "protective" defined as contamination levels in groundwater that are = applicable WV Surface Water Quality Standards at the point of compliance (POC), with the POC defined as the Site boundary, and;
- Reduction of groundwater contaminant levels at the POC over time and as practicable to support reasonably expected use.

The CMS Work Plan was approved August 12, 2005. The CMS identifies twenty one (21) potential Corrective Action technologies to address site-specific environmental concerns. The technologies involve a full range of potential corrective actions for the SWMUs including: removal, in-situ and ex-situ treatment, containment and institutional controls. Potential technologies for groundwater included natural attenuation, physical and hydraulic containment barriers, passive treatment walls, collection trenches and institutional controls. The initial list of twenty one (21) potential technologies was narrowed to a list of twelve (12) technologies for a more thorough evaluation. The list of technologies was reviewed with the Agencies and approved.

Six (6) Site Corrective Measures Alternatives were developed from various combinations of the potential Corrective Action technologies. All of the alternatives were assessed to be capable of meeting the approved Site CAOs and the proposed media-specific cleanup goals. Estimated present values of the alternatives range from $12 Million to $22 Million. A best-balanced alternative was selected and recommended from among the five alternatives, based on a comparative analysis of their abilities to provide protection of human health and the environment; their short-term and long-term effectiveness; their ability to reduce toxicity, mobility or volume of contaminants; implementability; costs; and community and State acceptance. The recommended Site Corrective Measures Alternative was further evaluated with respect to its consistency with statutory requirements related to protection of public health and the environment, cost effectiveness and preference for treatment as a primary element; and the consistency of the alternative with RCRA guidance and with recent Region 3 precedent.

Key premises for, and features of, recommended Site Corrective Measures are as follows:

- Site use will remain industrial.
- Institutional Controls will be an important protective element of the Corrective Measures.

- Development and implementation of site-specific, cost effective on-site treatments to address sources of contaminants in Site Soils that may leach to Site Groundwater will be key to improvement of the contaminant levels in Site Groundwater.
- Long-term containment of Site Groundwater will be required during the lengthy period of time needed to improve Site Groundwater quality.
- Protection of human health and the environment will be maintained and assured for the long-term throughout implementation of the Corrective Measures and confirmed on an on-going basis by performance monitoring at the POC.
- The goal for the recommended Corrective Measure is the attainment of Site CAOs and media-specific cleanup objectives.

The estimated present value of the recommended Site Corrective Measures is $12.6 Million. The implementation schedule for the proposed Corrective Measures assumes approval of the CMS in 4Q06 and projects initiation of engineering design in 1Q07 and initial installations of the measures beginning in early 2008. Implementation of Corrective Measures to address the sources of contaminants to site groundwater and to contain and improve site groundwater will continue for the long-term, as well as monitoring to confirm performance and continuing protection.

2.0 INTRODUCTION AND OBJECTIVES

The Corrective Measures Study (CMS) Report for the Bayer MaterialScience, LLC (Bayer) New Martinsville, West Virginia Facility (Site) was prepared by URS Corporation (URS) and Potesta and Associates, Inc. (Potesta), on behalf of Bayer pursuant to the CMS Work Plan which was submitted to the West Virginia Department of Environmental Protection (WVDEP) and the United States Environmental Protection Agency (U.S. EPA). The CMS Work Plan was approved by the agencies in a letter to Bayer dated August 12, 2005. This CMS is consistent with EPA's regulatory provisions contained in 40 CFR Part 264 Subpart F and the general guidance contained in contained in the Advance Notice of Proposed Rulemaking (61 FR, May 1, 1996, pg 19432-19455); the RCRA Corrective Action Plan (USEPA, 1994); the Handbook of Groundwater Protection and Cleanup Policies for RCRA Corrective Action (USEPA, April 2004); and other relevant guidance documents.

2.1 FACILITY OVERVIEW

The Bayer MaterialScience LLC (Bayer) New Martinsville manufacturing facility encompasses approximately 194 acres located along the eastern bank of the Ohio River, approximately 30 miles south of Wheeling, West Virginia, and 5 miles north of New Martinsville, West Virginia. The Site is bounded by the Ohio River to the west, a steep wooded hillside to the east, the PPG Natrium Plant to the north, and the small community of Proctor, WV to the south. **Figures 2-1 and 2-2** present maps illustrating the Site location.

Several engineering-consulting firms have conducted investigations of the facility over the past 25 years including Dames and Moore (1979), Green International (1980), GAI (1981) and Geraghty and Miller (1985, 1986, and 1988). As the initial step in the RCRA Facility Investigation (RFI) process, ICF Kaiser prepared a Description of Current Conditions (DOCC, 1995) Report that summarized key findings of the previous investigations. In the DOCC Report it was concluded that sufficient characterization of groundwater had been completed by the past investigations and the continuing groundwater monitoring activities at the Site, and that the only data needs for groundwater were related to the Corrective Measures Study (CMS). The RFI focused on evaluating thirty (30) RCRA Solid Waste Management Units (SWMUs) and collecting data to support a groundwater CMS. The final RFI report was prepared by IT Corporation (IT, 2001) and approved by EPA on October 13, 2004.

Thirty (30) solid waste management units (SWMUs) were evaluated during the RCRA Facility Investigation (RFI) (IT Corp., December 2001). The RFI evaluation process determined that all thirty (30) of the thirty (30) originally identified SWMUs passed the risk evaluation screening criteria, and warranted no further action for the direct exposure pathway. However, institutional controls to protect workers from potential exposure to subsurface soils are required at SWMUs 13, 18, 19, 22, 25 and 30. Sixteen (16) of the thirty (30) originally identified individual SWMUs are to be further evaluated in a CMS for site-wide groundwater, pursuant to the potential for each SWMU to leach constituents of interest (COIs) to groundwater at potentially unacceptable concentrations. The RFI process also resulted in Fourteen (14) of the sixteen (16) individual SWMUs remaining for evaluation pursuant to groundwater being consolidated into SWMU Groups, designated as Group A, B, C, and D. Main Plant SWMUs 21 and 27 were not included in any of the groups. Section 3.0 provides further details on the rationale and makeup of each SWMU Group and individual Main Plant SWMUs 21 and 27.

2.2 CURRENT SITE USE

The Site is currently in operation as an active industrial facility incorporating Bayer's manufacturing facilities for the production of plastics, polyurethanes, coatings and colorants. Other plant operations and support facilities are represented as well, including those for wastewater treatment, solid waste management, utilities, storm water control, plant operations and maintenance (O&M), Research and general administration. All of the SWMU Groups and individual SWMUs identified for further evaluation in the CMS are located within access controlled areas of the Site. The Site was formally designated as "Industrial" in a letter to Bayer from the U.S.EPA Region III, dated August 29, 2000, in which the agency provided the Site an approved Industrial Land Use Designation (USEPA, August, 2000).

A groundwater containment pumping and recovery treatment system has been in place and in continuous operation at the Site since 1986. A portion of the recovered groundwater is re-used by Bayer for non-contact cooling water and wash water and the remainder is sent directly to the wastewater treatment plant for biological and carbon treatment prior to discharge via the Site's permitted NPDES outfall.

An adjoining chemical facility, PPG, owns and operates a groundwater well located in the northwest portion of the Site. Groundwater pumped from this well is used by PPG for sub-surface brine deposit injection and solution pumping.

The Grandview Doolin Public Service District, located approximately one-half mile south of the Site supplies water to the town of Proctor. The District extracts groundwater from the alluvial aquifer using a Ranney well located on the eastern bank of the Ohio River. Bayer has installed monitoring wells between the Site and the Grandview Doolin well to confirm that there is no off-site migration of Site COIs via groundwater. There are also three (3) nearby residents that have wells as their source of water. Bayer analyzes the residents' wells in addition to Grandview Doolin's wells annually and has not found any evidence of contamination from Site COIs in these off-site wells.

2.3 HISTORICAL SITE USE

The Site was developed in 1954 by Mobay Corporation to produce polyester resin. Mobay Corporation changed its name to Miles, Inc. in 1992 and subsequently changed it name to Bayer Corporation in 1995. In 1956, the facility became the first in the U.S. to produce toluene diisocyanate (TDI), which is a polyisocyanate used in the manufacture of polyurethane foam products. In 1962, a polymeric isocyanate unit began production. The Site began iron oxide pigment production in 1980. Historically, several other products have been produced at the Site, most of which are used in the polyurethane production process. **Table 2-1** provides an overview of historical production operation at the Site (ICF, 1995).

Currently the Site operates three (3) production divisions consisting of plastics, polyurethanes, and coating/colorants. The plastics division produces thermo-plastics. The polyurethanes division produces polyurethane resins such as Methylene diphenyl diisocyanate, polyethers, and polyesters. The coatings and colorants division produces both aqueous and solvent based industrial coatings. There is one tenant at the Industrial Park – LANXESS that produces colored pigments from a crystallization process.

Polycarbonate was also produced at the Site from 1957 to 1982 when production was ceased (ICF Kaiser, 1995). Toluene Diisocyanate (TDI) was produced from 1956 until 2005; Iron oxide pigments manufactured from mononitrobenzene (MNB) and iron chips were produced on-site from 1980 until 2002.

Various raw materials have been utilized at the Site since operations began over fifty (50) years ago in 1954. **Table 2-2** provides a summary of the primary historical raw materials and products that have been utilized or produced at the Site (ICF, 1995).

TABLE 2-1: SITE HISTORICAL PRODUCTION AND OPERATIONS

Date	Events
1954 - 1955	Plant commenced operation to produce polyester resin; Polyester-I Facility opens
1956	Monoisocyanate, toluenediamine (TDA), toluene diisocyanate (TDI) production begins
1957	Multipurpose isocyanate produced; polycarbonate production begins
1961	Dinitrotoluene (DNT) production begins
1962	Batch production of Methylene dianiline (MDA), Mondur (MR) isocyanate and methylene diphenyl diisocyanate (MDI) begins; central HCl absorption unit installed; polycarbonate production shut down
1963	Reformer #1 isocyanate processing begins; new TDA/TDI production facility constructed
1964	Original TDA/TDI facility closed; polycarbonate production resumed
1965	Mononitrobenzene (MNB) production begins; aniline and MR-1 isocyanate production begins
1967	MDA-II production begins; nitric acid production begins, Reformer #2 isocyanate processing begins
1969	Polyol production begins; Mondur CB isocyanate production begins
1970	Polyester-II resin production begins; Texin urethane resin production begins; MDA/MR/MDI-II production begins
1971	Wastewater treatment facility opened
1978	PHD Polyol production begins
1980	Iron oxide pigment facility complete and production started
1982	TDI isomer separation process begins; polycarbonate production shut down
1983	Aniline production shut down
1986	Original polyester production unit shut down; dispersion unit opens
1987	Monoisocyanate production shut down
1988	Fluid Bed Incinerator for waste incineration put into operations
1993	Off-gas Thermal Oxidizer begins operation at the HCl plant
1994	MNB production shut down
1999	TDA, DNT, and Nitric Acid operations shut down
2002	MR-I and Iron Oxide/Aniline process shut down
2005	TDI and Coating shut down

TABLE 2-2: HISTORICAL RAW MATERIALS AT THE SITE

Raw Materials Historically Utilized at Site	Dates
Phosgene, Chlorobenzene, p-Chloroaniline, Aniline, o-Toluidene	1955 – 1987
TDI, MDI, MR, Polyols, Solvents, Glycols	1955 – 1999
DNT, Methanol, Nickel, Hydrogen	1956 – 1995
TDA, Chlorine, o-Dichlorobenzene, Carbon Monoxide (phosgene intermediate)	1956 – present
Phosgene, Chlorobenzene, Bisphenol A, Methylene Chloride	1957 – 1986
HCl from off-gas of isocyanate units	1960 - present
Toluene, Sulfuric Acid, Nitric Acid, Caustic	1961 – 1999
Formaldehyde, HCL, Caustic, Aniline	1962 - present
MDA, Chlorine, Chlorobenzene, Carbon Monoxide (phosgene intermediate)	1962 - present
Ammonia, Oxygen	1962 - present
Natural Gas, Caustic, Monoethanol Amine	1963 - present
Benzene, Sulfuric Acid, Nitric Acid, Caustic	1965 – 1994
MNB, Benzene, Methanol, Nickel	1965 – 1983
TDI, Methyl Ethyl Ketone, Xylene, Glycols, TMP	1969 – present
Ethylene Oxide, Propylene Oxide, Sucrose, TDA, Potassium Hydroxide, Glycols	1969 – present
MDI, Diols, Glycols	1970 – present
Dilute Sulfuric Acid	1979 - 1994
TDI	1982 – present
MNB, Scrap Iron	1980 – 2002
TDA, DNT, Nitric Acid	Shut down in 1999
TDI and Coatings	Shut down in 2005
Iron Oxide, Aniline	Shut down in 2002

2.4 OBJECTIVES

The objectives of the CMS are based on the previously approved CMS Work Plan and are summarized as follows:

- Develop and present Corrective Action Objectives (CAOs) for Site Soils and Site Groundwater that will serve as the basis for the subsequent evaluations presented in the CMS.
- Present a summary of Site Current Conditions.
- Develop and present the evaluation results of the potential corrective measures technologies for SWMU Groups A, B, C and D; individual SWMUs 21 & 27; and Site Groundwater, pursuant to the CAOs for Site Soils and Site Groundwater..
- Develop and present a recommended corrective measures alternative to achieve the CAOs.

2.5 CMS ORGANIZATION

The CMS Report consists of the following sections:

- **Section 1.0 – Executive Summary**
- **Section 2.0 – Introduction and Objectives**
- **Section 3.0 – Summary of Current Conditions:** This section presents a summary of the Site's physical setting, subsurface characteristics, SWMU status, environmental status and the status of on-going corrective actions.
- **Section 4.0 – Corrective Action Objectives:** This section reviews the rationale and presents the approved Corrective Action Objectives for the Site.
- **Section 5.0 – Corrective Action Technology Selection:** This section details the identification, screening and selection of potentially applicable corrective action technologies for SMWU Groups A, B, C and D; SWMUs 21 & 27; and Site Groundwater pursuant to the CAOs.
- **Section 6.0 – Evaluation and Selection of the Corrective Action Technologies:** Potentially applicable corrective action technologies are evaluated for SMWU Groups A, B, C and D; SWMUs 21 & 27; and Site Groundwater.
- **Section 7.0 – Recommended Site Corrective Measures:** Site-wide Corrective Measure Alternatives are selected, evaluated and compared, and the best-balanced alternative to achieve the Site CAOs for Site Groundwater and Site Soils is recommended.
- **Section 8.0 – References:** This section presents the references utilized during the preparation of the CMS.

- **Figures, Tables, and Appendices:** The figures, tables, and relevant appendices referenced throughout the CMS are presented in these sections.

3.0 SUMMARY OF CURRENT CONDITIONS

This section of the CMS presents a summary of current conditions at the Site related to the physical setting, subsurface characteristics, areas of concern, and environmental quality conditions. The information presented generated herein follows a review of previously generated site-specific documents.

3.1 *PHYSIOGRAPHY*

The New Martinsville Facility is situated within the Ohio River Valley at the base of the West Virginia Northern Panhandle in Marshall and Wetzel Counties, approximately 5 miles north of the city of New Martinsville, WV (see **Figure 3-1)**. This area is part of the Appalachian Plateau physiographic province, described as a highly dissected plateau characterized by rugged topography, steep slopes, and strong relief, with elevations ranging from about 600 feet to more than 1,600 feet above mean sea level (ft-msl). The Ohio River receives virtually all of the area's natural drainage via tributaries, surface runoff, overland flow and groundwater discharge. Stream erosion in conjunction with weathering and mass wasting of slope materials are largely responsible for the existing topography of the region (Price and others, 1956).

Exceptions to the typical rugged topography of the region occur in areas adjacent to the Ohio River where the carving of terraces into older and higher glaciofluvial outwash deposits has created relatively level or gently inclined strips of land that tend to parallel the course of the Ohio River. These land features, commonly referred to as bottoms or bottomlands, are developed from Pleistocene glacial outwash deposits that have been down-cut by historical stages of the Ohio River. The terraces are comprised primarily of gravel, sand, and silt. Surficial sediments of lower terrace features contain increasing amounts of silt and clay, which probably represent recent floodplain deposits.

The New Martinsville Facility is located on a relatively flat bottomland referred to as Wells Bottom and is bounded by an industrial facility to the north, the Ohio River to the west, Route 2 and steeply sloped terrain to the east, and the small town of Procter, WV to the south. A 100-year flood level elevation of 641 ft-msl has been estimated for the Wells Bottom region. The Ohio River has a reported mean flow rate of 24,000 cubic feet per second (cfs) and a low flow rate of 5,300 cfs. The Hannibal Dam, located downstream in New Martinsville, controls the water level and keeps river pool elevations between 620 and 624 ft-MSL during normal flow periods. The water quality of the Ohio River is reported to be suitable for many industrial uses.

Figure 3-1 shows a base map of the New Martinsville Site. **Figures 3-2 and 3-3** present two (2) recent aerial views (circa 1996) depicting the overall industrial setting of the Site along with the surrounding land. **Figure 3-2** is annotated to show the various entities/properties present in the land surrounding the Site. **Figure 3-3** is annotated to depict the general locations of the various SWMUs or SWMU Groups at the Site as well as to depict recent surface/drainage modifications at the Site. The recent changes primarily address the rerouting of the Beaver Run Stream and backwater previously located immediately adjacent to SWMU Group A. Beaver Run Stream was rerouted by Bayer in 2004 and Beaver Run Stream and the associated backwater pond were filled. The hatched areas in **Figure 3-3** depict the previous location of the Beaver Run Stream and backwater pond and the highlighted area presents the current location of the rerouted Beaver Run Stream.

Groundwater constitutes an important source of water supply in the New Martinsville area. The main water-bearing unit, the Ohio River Valley Alluvial Aquifer, is composed of the medium to coarse sand and gravel outwash deposits. Yields from this aquifer range from 100 to several thousand gallons per minute (gpm) and natural water quality is generally good (Price and others, 1956).

Climate in the area is typical of a temperate continental zone with warm summers and cold winters averaging 73 F and 34 F, respectively. Precipitation is ample and fairly well distributed throughout the year, averaging approximately 43 inches per year, with maximum and minimum rainfall occurring in summer and fall, respectively (Soil Conservation Service (SCS), 1960).

3.2 *SITE GEOLOGY*

The Northern Panhandle region of West Virginia is underlain by Paleozoic-age sedimentary rocks consisting mainly of conglomerates, sandstones, siltstones, shales, fresh-water and marine limestones, coals, and lesser amounts of chert, iron ore, and rock salt and other evaporates (Price and others, 1956). Coal deposits, which mainly occur in Pennsylvania-age and, to a lesser extent, Permian-age rocks, are a very important natural resource of the Ohio River Valley area. Rock salt and natural brines of Silurian-age strata are of local importance to chemical industrial for the manufacture of chlorine, bleaches, and caustic soda (Geraghty & Miller, 1985a).

In the hilly, more elevated areas of the Panhandle, rock units are generally overlain by a thin to moderately thick layer of residual soils from varying thicknesses that have been formed in place by the disintegration of underlying rocks and by the accumulation of natural organic material. These soils are usually relatively fertile and well drained, and are capable of supporting woodland, cropland, and pasture (SCS, 1960). Owing to the hilly topography characterizing these upland areas, the soils tend to be fairly susceptible to erosion (Geraghty & Miller, 1985a).

In areas adjacent to the Ohio River, steep valley walls with outcropping rocks of Pennsylvanian and Permian-age descend to relatively flat-lying bottomland alluvial deposits. Owing to down-cutting by the Ohio River, alluvial deposits commonly exhibit a stepped (or terraced) topography with the highest surface elevations occurring near the valley wall and successively lower elevations occurring toward the river. Throughout the southern half of Wells Bottom, surficial sediments are composed of fine sands, silts, clays, and mixtures of these, probably representing floodplain deposits laid down by the Ohio River. In areas adjacent to the valley wall, unconsolidated deposits pinch out against bedrock strata and are capped with colluvium (clay, silt, and rock fragments) derived from weathering and mass-wasting of highlands and the valley wall (Geraghty & Miller, 1985a). The colluvium tends to thin toward the river.

Fine-grained surface deposits are underlain by a thick, continuous body of glacial outwash composed of medium to coarse sand and gravel. These coarse-grained deposits, which aggraded the Ohio River Valley during retreat (i.e., melting) of Pleistocene-age glaciers, form the main water-bearing unit of the alluvial aquifer (Geraghty & Miller, 1985a).

Outwash deposits are underlain by Paleozoic-age bedrock, which is encountered beneath the Facility at depths generally not exceeding 70 feet below ground surface (ft-bgs). The buried bedrock surface slopes steeply away from the valley walls and flattens-out beneath central and near-river areas of the bottomland, forming a large U-shaped trough (i.e. the Ohio River Valley) (Geraghty & Miller, 1985a).

3.3 *SITE HYDROGEOLOGY*

The Ohio River Valley Alluvial Aquifer is comprised of glacial outwash derived sand, silty- to sandy- clay and gravels deposited on a bedrock base and represents the main aquifer beneath the Wells Bottom area. Most sand and gravel materials beneath Wells Bottom are thought to represent outwash that aggraded to the Ohio River Valley during retreat of the Pleistocene glaciers. The Ohio River Valley Alluvial Aquifer is hydraulically connected with the Ohio River throughout Wells Bottom, and is capable of yielding millions of gallons of groundwater per day with sustained pumping. If extraction wells located adjacent to the river are pumped at a high enough rate for sustained periods of time, it is possible to reverse the natural groundwater flow gradient, which normally would be toward the Ohio River.

Finer grained silty and sandy clay commonly cap or overlies the glacial sand and gravel. An accumulation of finer sediments adjacent to the Ohio River represent recent deposition of floodplain alluvium. Silty to sandy clay deposits underlying the upper tiers of Wells Bottom represent deposition of locally derived colluvium and detrital materials from weathering and mass wasting of uplands and valley walls. Discontinuous zones of shallow perched water occur sporadically throughout the fine-grained flood-plain and colluvial materials, which, constitutes a discontinuous aquitard to the downward percolation of recharge waters.

Beneath Wells Bottom, the alluvium is underlain by Paleozoic-age bedrock at depths ranging from between approximately 50 to 100 ft-bgs. The upper 100 feet of bedrock generally consist of shale and competent limestone. The bedrock surface dips from east to west from the valley wall toward the Ohio River. Yields from bedrock wells are typically low [e.g. 15 galls per minute (gpm) or less] and the quality of bedrock water is considered poor due to elevated concentrations of total dissolved solids (Geraghty & Miller, 1985).

Figures 3-4 through 3-7 present graphical representations of the generalized conceptual site model (CSM) for the Site. **Figures 3-4 & 3-6** present conceptual North-South cross sections through the Site for SWMU Group A and SWMUs within the main plant area respectively, illustrating the generalized geology at the Site, consisting of fill and fine-grained alluvial deposits overlying the coarser glacial sand/gravel alluvial aquifer and the underlying bedrock unit. Also depicted in the figures is the generalized nature of Site Groundwater.

The alluvial aquifer is generally present everywhere beneath the Site and is the focus of the current site-wide groundwater pump and treat recovery system. **Figures 3-4 & 3-6** also illustrate the general locations of the various SWMUs or SWMU Groups with respect to the site conditions. In general, with the exception of SWMU Group A, the SWMUs or SWMU groups are typically limited to the overlying fill and fine-grained alluvial deposits above the water table of the alluvial aquifer. **Figures 3-5 & 3-7** present conceptual East-West cross sections through the Site for SWMU Group A and SWMUs within the main plant area respectively, illustrating the same features as discussed for **Figures 3-4 & 3-6**. Perched water is intermittently found in discontinuous lenses across the Site, primarily in the area of SWMU Group A (i.e. in the southern portion of the Site). Perched water has a fairly direct response to recharge events and tends to be subject to short-term fluctuations in water levels.

3.4 *SUMMARY OF SOLID WASTE MANAGEMENT UNITS (SWMUS)*

Between 1985 and 1988, six (6) reports were completed in an effort to identify all SWMUs at the Site under the HSWA Permit and Administrative Consent Order (ACO). The first report identified thirteen (13) SWMUs as part of the RCRA Part B Permit Application procedure. A subsequent Preliminary Assessment Report (PAR) (SAIC, August 1986) divided these thirteen (13) SWMUs into forty-two (42) separate SWMUs and added eighteen (18) additional SWMUs, bringing the total to sixty (60) SWMUs. The PAR indicated that eighteen (18) of the sixty (60) SWMUs did not require corrective action and further noted that six (6) SWMUs required RCRA closure. Of the remaining thirty-six (36) SWMUs, twenty (20) were identified under the ACO, nine (9) were identified as requiring additional investigation to determine if corrective action was required, and seven (7) SWMUs were identified as requiring remedial investigation or immediate corrective action.

The 1987 Waste Accumulation Areas Report (Geraghty & Miller, December 1987), completed to satisfy HSWA requirements, identified seventy (70) Solid Waste Accumulation and Staging Areas or sites. Of these, fifty-three (53) sites were recommended for no further action (NFA); eight (8) sites were recommended for surface cleaning; and nine (9) sites were recommended for further study. The eight (8) sites were addressed via surface cleaning and approved as clean by the U.S.EPA on March 31, 1988 with no further action required. The fourth report, the Existing Process Trench Report (IT Corporation, June 1988), recommended additional studies for the existing process trench area.

The RCRA Facility Assessment (RFA) was the fifth report and was submitted to the U.S.EPA on June 28, 1998, in accordance with HSWA requirements. The RFA reviewed the nine (9) sites identified in the Waste Accumulation Areas Report and four (4) additional sites specified in the HSWA Permit. Of the thirteen (13) sites addressed in the RFA, two (2) were being investigated under the ACO, seven (7) were recommended for NFA, and four (4) sites were recommended for further study. The June 1988 Procedures and Results of Investigation Report identified twenty-three (23) SWMUs and recommended further study for these units. Of all the SWMUs identified for the Site, thirty (30) were ultimately recommended for inclusion in the RCRA Facility Investigation (RFI).

The final RFI report was prepared by IT Corporation (IT, 2001) and approved by EPA on October 13, 2004. In the approved RFI, thirty (30) SWMUs were evaluated using a screening risk assessment process that included comparison of media constituents to USEPA Region III Risk-Based Concentrations (RBCs) for industrial and residential uses or the USEPA Region III Soil Screening Levels (SSLs). On-site worker exposures were evaluated for the upper 2 ft soil interval, and onsite construction worker exposures were evaluated for the 0-5 ft soil interval. Soil constituents at all depth intervals were compared to the SSLs. The SSLs were used as screening criteria to assess the potential to leach contaminants to groundwater. Site-Specific SSLs were calculated to further evaluate if constituents within the unsaturated zone at levels exceeding SSLs could potentially migrate to groundwater at concentrations of concern.

In addition, constituents of interest (COIs) were identified. COIs are defined as constituents whose detected concentrations exceeded the respective RBC(s). COIs were evaluated in the RFI for carcinogenic or non-carcinogenic risks to on-site workers, depending on the nature of the specific chemical compound.

The RFI evaluation process resulted in all thirty (30) SWMUs being recommended for no further action based on the risk screening evaluation. However, the RFI further concluded that sixteen (16) of the thirty (30) originally identified individual SWMUs be further evaluated in a CMS for site-wide groundwater, pursuant to their potential to leach COIs to groundwater at potentially unacceptable concentrations. The RFI process also resulted in the sixteen (16) individual SWMUs being consolidated into SWMU Groups, designated as Group A, B, C, and D, and individual SWMUs 21 & 27 as follows:

(1) SWMU Group A (SWMUs 1-4)

(2) SWMU Group B (SWMUs 5 and 6)

(3) SWMU Group C (SWMUs 7, 8, 9 and 11)

(4) SWMU Group D (SWMUs 10, 12, 15 and 16)

(5) SWMU 21

(6) SWMU 27

The locations of the various SWMUs / SWMU Groups, as outlined above, are presented graphically in **Figure 3-1**.

RFI Table 8-1 summarized conditions and the recommendation status for the individual SWMUs and SWMU Groups. **Table 3-1** presents the information contained in RFI Table 8-1 for these SWMUs and SWMU Groups.

3.5 *GROUNDWATER QUALITY SUMMARY*

The main aquifer beneath the Bayer facility is the Ohio River Valley Alluvial Aquifer. The alluvial aquifer beneath the Bayer facility consists generally of an elongated lens of up to 20 feet of fine sand with varying amounts of silt overlying a medium to coarse sand and fine gravel outwash deposit that averages 20 to 30 feet in thickness. The base of the alluvial aquifer extends to the top of bedrock, which is found at depths generally not exceeding 70 ft-bgs (Geraghty & Miller, 1998a)[2]

Localized areas of perched water are separated from the alluvial aquifer by a discontinuous silty clay 'confining layer', where natural silt and clay-rich alluvium has been overlain with more permeable fill. The RFI concluded that perched water flow is primarily in a downward direction, ultimately discharging to the alluvial aquifer. For the main plant area, lateral flow of the discontinuous perched water roughly coincides with the natural drainage pattern prior to infilling. The RFI concluded that there was some potential for perched water within the South Landfill (SWMU 1 within SWMU Group A) to discharge laterally into the Beaver Run surface water. However, subsequent to this report, Bayer has further minimized this potential by rerouting Beaver Run and infilling the original channel.

The alluvial aquifer beneath the Site is currently pumped by three (3) groundwater recovery wells, each collecting approximately 150 gpm. In addition, an adjacent industrial facility, PPG, extracts groundwater periodically from a production well on the northwest portion of the Facility. Across the facility, the aquifer drawdown is at or near the base of the overlying confining layer. The main source of aquifer recharge is from the Ohio River. The aquifer also receives recharge from overlying alluvial deposits and to a limited degree, from lateral discharges from valley wall bedrock. Under pumping conditions, groundwater flow within the alluvial aquifer is radial toward the center of the Site under the main plant area, with induced river flow becoming the main source of aquifer recharge (Geraghty & Miller, 1985a).

Groundwater sampling has been conducted at the Site since 1985 and has indicated environmental impacts to the alluvial aquifer from volatile and semi volatile organics compounds (VOCs and SVOCs). The RFI included a screening groundwater risk evaluation utilizing groundwater data available from on-site and off-site wells. Groundwater analytical results were compared to USEPA MCLs for drinking water or to USEPA Region III RBCs for tap water. Twenty-two (22) constituents in on-site wells exceeded at least one of these screening criteria. No constituents from offsite wells were in excess of the screening criteria. COIs found in the on-site groundwater consisted primarily of VOCs and SVOCs. The RFI concluded that the affected groundwater is contained on-site. More recent groundwater data from the 2003 Groundwater Monitoring Report (MFG, Inc., 2004) confirmed that the alluvial aquifer contaminant plume is stable and is being contained on-site by existing recovery well operations. Since the recovery wells were installed in 1986 all groundwater elevation readings since then have demonstrated successful and consistent plume hydraulic containment.

The primary VOCs that have been historically detected in groundwater at the Site include:

- 1,1,1-trichlorethane
- 1,2-dichlorobenzene
- 1,4-dichlorobenzene
- chlorobenzene
- benzene
- toluene
- trichloroethene
- trichlorofluoromethane

Of these eight (8) compounds, chlorobenzene, 1,2-dichlorobenzene, and benzene represent the most frequently detected VOC components.

The most frequently historically detected SVOCs within groundwater at the Site include:

- 1,2-dichlorobenzene
- 2,4-dinitrotoluene
- bis(2-ethylhexyl)phthalate
- nitrobenzene
- o-nitrotoluene

Detections of 2,4-toluenediamine, 2,6-dinitrotoluene, 4,4-methylenedianiline, 5-nitro-o-toluidine, aniline, bisphenol A, m-nitrotoluene, o,p-toluidine, p-chloroaniline, and p-nitrotoluene are also reported.

All metals analyzed have been historically detected in groundwater at the Site; however, the concentrations are generally within the ranges expected for background levels.

Perched water is impacted in various areas of the Site by both VOCs and SVOCs, particularly in the south landfill area (SWMU Group A). The migration path for the perched water is believed to be primarily downward into the alluvial aquifer.

The configuration of the plumes of total VOCs and SVOCs in the upper and deeper portions of the alluvial aquifer are similar, with concentrations in the deep portion being much lower than those found in the upper portion.

[2] Page 7-5, Final RFI Report, Revision 1, December 2001, IT Corp.

The complex intermingling and widespread distribution of organic compounds beneath the facility have resulted from historical releases from the multiple SWMUs. Changes in dominant flow directions by variations in both pumping center locations and rates throughout the plant's history have further complicated attempts to link groundwater contamination to individual sources. As a result of these factors, observed groundwater contamination characteristics cannot reliably be linked to individual SWMUs.

Groundwater within the upper bedrock is considerably more mineralized than groundwater within the alluvial aquifer. Bedrock monitoring wells also exhibit higher pH, higher alkalinity, and higher concentrations of sodium, chloride and barium than are observed in the associated deep alluvial aquifer monitoring wells (Geraghty & Miller, 1988a). These water quality trends suggest that the bedrock strata beneath the Facility have not been fully flushed of natural connate waters (i.e. waters incorporated with the sediments at the time of deposition. The occurrence of waters with similar composition at shallow depths within the Ohio River Valley bedrock strata have been recorded elsewhere (Price and others, 1956).

Organic compounds have been sporadically detected in samples from the bedrock monitoring wells. However, these low or trace concentrations have been reported as representative of false-positive results due to cross-contamination during sample collection and/or analysis, based on associated quality control sample results.

3.6 RFI SUMMARY

The media potentially affected by releases at the Site and evaluated in the RFI include soil, surface water, groundwater and sediments. The conclusions and recommendations presented in the RFI were based on the combined results of all three RFI phases. Soils were investigated on a SWMU basis during Phases 1 & 2 of the RFI and groups of SWMUs in Phase 3. The SWMUs were grouped based on proximity, historical knowledge and analytical results.

Human health risk was a critical component in the interpretation of soil, surface water and sediment data in the RFI decision process. The primary purpose of the risk assessment was to decide the appropriate corrective action to take, if any, for soil at each SWMU or SWMU group. The risk assessment considered both residential and industrial land use. However, because Bayer is an active industrial facility and has been recognized as such by the USEPA, all recommendations for corrective actions were based on the assumption of continued industrial land use into the future. The recommendations were:

- No Further Action (NFA) for surface water and sediments;
- Institutional Controls to protect workers from potential exposure to subsurface soils for SWMUs 13, 18, 19, 22, 25 and 30, and for each of the SWMUs and SWMU groups evaluated during RFI Phase 3;

- An engineered soil cover for SWMU Group A in combination with rerouting of Beaver Run to eliminate any future potential impact to surface water and potential hazards due to stream erosion.
- A CMS to define actions, if any, required to expedite groundwater quality improvement, which may include addressing potential leaching to groundwater associated with some of the Phase 3 SWMUs / SWMU groups.

3.7 Ongoing Corrective Actions

Pursuant to the RFI recommendations stated in the preceding section, the following relevant actions by Bayer were either already in progress or have been taken pursuant to the recommendations:

3.7.1 Institutional Controls

Pursuant to the RFI recommendation, Bayer has initiated health and safety work practices for on-site workers who could potentially come into contact with SWMUs or Site groundwater. Engineering controls will be installed where appropriate to prevent unsafe exposures.

3.7.2 SWMU Group A Actions

In 2004, Bayer relocated Beaver Run, an on-site tributary of the Ohio River. A portion of the stream created a backwater on the east side of SWMU Group A (i.e. near the South Landfill). The backwater pond was drained and the stream was relocated to convey water to Dry Run. A new wetland was also constructed. The former stream channel now contains a storm water drainage channel that discharges to a sedimentation basin, which discharges into the Ohio River. This action eliminated the backwater adjacent to SWMU Group A and further reduced the potential for leaching of COIs into surface water. Soil covers and fencing around SWMU Group A have been installed. A recommendation by Bayer to install an engineered soil cover on SWMU Group A contemporaneous with the relocation of Beaver Run was not approved by the Agencies.

3.7.3 Groundwater Quality Improvements & Protective Measures

Bayer has maintained groundwater recovery wells at the Site since 1986. Currently, three (3) groundwater recovery wells are in operation in the Main Plant Area, continuously extracting an average of 474 gpm (total) of affected groundwater from the alluvial aquifer beneath the Site. All recovered groundwater is treated in Bayer's on-site biological wastewater treatment facility prior to discharge to the Ohio River. Bayer's wastewater treatment discharge is regulated under an NPDES discharge Permit. In the 20 years of operation of the groundwater pump and treat system, an estimated 4.2 billion gallons of water have been extracted for treatment and 725,000 pounds of organic material have been removed from the alluvial aquifer.

Bayer performs regular monitoring of the groundwater between the Site and the Grandview Doolin Ranney extraction well one-half mile to the south to confirm that there is no off-site migration of Site COIs via groundwater. Bayer analyzes the Grandview Doolin wells annually and has not found any evidence of contamination from Site COIs. There are also three (3) nearby residents that have wells as their source of water. Bayer analyzes the residents' wells annually and has not found any evidence of contamination from Site COIs in these off-site wells.

4.0 CORRECTIVE ACTION OBJECTIVES

Corrective Action Objectives (CAOs) are general descriptions of what corrective measures at the Site are intended to accomplish. The RFI, summarized in **Section 3.0 Summary of Current Conditions,** concluded that Site areas requiring further study pursuant to this CMS are:

1. SWMU Groups A, B, C and D; SWMU 21; and SWMU 27 - relative to the potential for COIs to leach from the SWMU affected soils to Site Groundwater at concentrations of potential concern, and;
2. Site Groundwater.

Therefore, CAOs have been developed for Site Soils and Site Groundwater and approved by the Agencies. The CAOs are premised on the Site remaining industrial. The approved CAOs are shown in detail in **Table 4-1**. The CAOs are media specific and time dependent (short-term and intermediate/long-term timeframes). In summary, the CAOs are as follows:

Overall CAO:

- At all times, prevent unacceptable human exposure (carcinogenic risk > 1 x 10^{-6} and Hazard Index > 1) from affected Site Groundwater and Site Soils

Site Soil CAOs:

- Prevent unacceptable industrial worker exposures to shallow (0 to 2 ft-bgs) surficial soil COIs (i.e. detected contaminants),
- Prevent unacceptable construction worker exposures to subsurface (0 to 5 ft-bgs) soil COIs, and
- Prevent unacceptable construction worker exposures to soil COIs (at all depths).

Site-wide Groundwater CAOs:

- Prevent unacceptable human exposures to recovered contaminated groundwater;
- Maintain current groundwater recovery well system operation for groundwater collection and plume hydraulic containment within the Site boundary;
- Provide for the continued control of potential off-site migration of contaminated groundwater to a level that is protective of surface water quality, and;
- Implement reasonable efforts to eliminate or mitigate further releases of contaminants from SWMUs (using the site boundary as the point of compliance).

4.1 MEDIA SPECIFIC CLEANUP GOALS

Media specific cleanup goals are to be based on EPA guidance, public health and environmental criteria, information gathered during the RFI and the requirements of any applicable Federal or State Statutes. Media specific goals are site specific concentrations in a given media that a final remedy must achieve for the remedy to be considered complete (Region III Model CMS Outline). The Point of Compliance is the location or locations at which media cleanup levels are achieved (FR 61 III.C.5.d, pg 19450). The term “media cleanup levels” typically refers to site and media specific concentrations of hazardous constituents, developed as part of the overall cleanup standards for a facility. The term “media cleanup standard” refers to broad cleanup objectives; it often includes the more specific concepts of “media cleanup levels”, “points of compliance,” and “compliance timeframes”. Media cleanup standards (and levels) should reflect the potential risks of the facility and media in question by considering the toxicity of the constituents of concern, exposure pathways, and fate and transport characteristics. (FR 61 III.C.5.c, pg 19449).

One of the four threshold criteria for remedy selection for Corrective Action is that the selected remedy “attain media cleanup standards”. The attainment of media cleanup standards does not necessarily entail removal or treatment of all contaminated material above specific constituent concentrations. Depending on the site specific circumstances, remedies may attain media cleanup standards through various combinations of removal, treatment, engineering and institutional controls. For example, in situations where waste is left in place in an engineered or under a cap, media cleanup standards can be attained in part through long-term engineering and institutional controls (FR 61 III.C.5.(g).b, pg. 19449).

Consistent with RCRA Guidance discussed above where wastes will be left on site, the POC for the Bayer Site has been defined in the CAOs as the Site boundary. This approach to the groundwater POC is generally referred to as the “throughout the plume/unit boundary POC.” This approach is consistent with the groundwater POC described in the preamble to the Superfund program’s National Contingency Plan (NCP, page 8713 and 8753, Federal Register March 8, 1990) (FR 61 III.C.5.(g).d, pg. 19450). Therefore, the proposed “media cleanup level” for Site groundwater is focused on protection of the surface water body into which the groundwater would otherwise discharge (i.e. absent containment):

- Site related COI concentrations = their respective MCL and WV Surface Water Quality Standard at the POC.

When containment is part of the final remedy, facilities and regulators are encouraged to develop systems to monitor the effectiveness of the containment (Handbook of Groundwater Protection and Cleanup Policies for RCRA Corrective Action, Final Cleanup Goals, pg. 4.6). Therefore, the following criteria are proposed as measures-of-effectiveness of the containment element of the Final Remedy:

- Periodic confirmation that no Site related COIs have reached the drinking water wells of any potential receptors, and;
- Periodic documentation of an inward gradient for the alluvial aquifer at the Site boundary.

The specific issue to be addressed by this CMS with respect to Site Soils is the potential for Site Soils associated with certain SWMUs to leach COIs to Site Groundwater in concentrations of potential concerns, based on screening of the Site Soil COI concentrations against the site specific SSLs. Site soils containing COIs in excess of the SSLs are to be addressed as a potential source for the COIs identified in groundwater. Therefore, consistent with the site-specific risks associated with Site Soils and the approved CAOs, the proposed cleanup goal for the Site is:

- Achieve reduction of Site Soil COI contaminant levels over time, as practicable, to support attainment of Site Groundwater cleanup goals.

5.0 CORRECTIVE ACTION TECHNOLOGY SELECTION

Potential Corrective Action technologies have been identified and evaluated with respect to each SWMU, SMWU Group and Site-wide Groundwater. Each potential technology has been evaluated with respect to its applicability to the facility and its potential to achieve the Site CAOs – either as a standalone technology or in combination with other technologies. A wide-range of potentially applicable Corrective Action technologies were considered, including the use of both traditional and innovative approaches. In the final recommendation, alternatives utilizing proven Corrective Action technologies will be given preference as prescribed in USEPA directive (USEPA, 1993). The array of potential Corrective Action technologies to meet the media CAOs include technologies from all of the following categories:

- **Site Soils -** Engineered covers and containment barriers; removal, with disposal and/or treatment; insitu treatment/stabilization; and institutional controls.
- **Site-Wide Groundwater -** Containment via extraction and treatment; passive treatment barriers; active in-situ treatment; and institutional controls.

To facilitate the technology evaluation and consistent with the RFI, Site SWMUs, SWMU groups and Site-wide Groundwater will be consolidated as follows:

- ➢ SWMU Group A
- ➢ Main Plant Area (SWMU Groups B, C and D and SWMUs 21 & 27)
- ➢ Site-wide Groundwater

Following are descriptions of the SWMUs within each of the consolidated areas, with relevant information pursuant to the technology screening process:

SWMU GROUP A

SWMU Group A contains the South Landfill (SWMU 1) and associated waste management areas: Sludge Lagoon (SWMU 2), Hydroblasting Station (SWMU 3) and the Ash Lagoon (SWMU 4). The SWMU Group A area is entirely within the property boundary of the Site, which has controlled access. The area of SWMU Group A is estimated to be approximately 7 acres. See **Figure 3-1**.

The South Landfill, Sludge Lagoon and possibly the Ash Lagoon, have a portion of their waste materials at or near elevation 600 feet mean sea level (ft-msl). This elevation datum is beneath the base of the alluvial aquifer confining layer in the area, which is at approximately elevation 620 ft-msl. The potentiometric surface of the alluvial aquifer is also at approximate elevation of 620 ft-msl. Historically, when the landfill was actively being used, the waste fill area was operated above the local water table. However, the water table conditions changed as a result of an approximate 20 foot rise in Ohio River pool elevation (current average 620-624 ft-msl) caused by the Hannibal Dam construction in 1973.

As discussed previously, the former Beaver Run pond on the east side of the landfill was drained, and Beaver Run was rerouted in 2004. This measure significantly reduces the potential for contaminant leaching of the SWMU lower waste deposits and a reduction in the potential for leachate migration to surface water.

Site worker exposure to contaminated soils is limited because of the isolated detections of soils containing constituents above industrial USEPA Risk-Based Concentration (RBC) levels in the upper 5 feet interval. The only constituent detected above the RBC levels was 2,4-toluenediamine (TDA). TDA was found above the RBC in only 1 of the 26 SWMU Group A samples taken in the 0-5 feet below ground surface (ft-bgs) interval.

Groundwater CAOs focus on control of migration of perched water to surface waters (short and long-term) and reduction of contaminant leaching to groundwater as part of the intermediate/long-term goal of improvement of groundwater quality. The primary chemical constituents that exceeded the USEPA Soil Screening Levels (SSLs) for leaching to groundwater included one VOC (benzene); five SVOCs (dichlorobenzenes, nitrobenzene, 2,4- dinitrotoluene, 2,6- dinitrotoluene, phenol and p-chloroaniline); and two metals (cadmium and nickel).

MAIN PLANT AREA (MPA)

The Main Plant Area (MPA) contains the remaining Site SWMUs. The MPA is within the operating boundaries of the plant, which has controlled access. The SWMU Groups and individual SWMUs within the MPA have significant similarities, including surface and subsurface conditions and contaminant types that allow potential Corrective Action technologies to be evaluated for the MPA as a whole to facilitate the CMS process. Individual differences in the SWMUs, significant to a particular Corrective Action technology evaluation, are addressed as appropriate. A brief summary of the individual MPA SWMU Groups and individual SWMUs follows (See **Figure 3-2** for the MPA location).

SWMU GROUP B

SWMU Group B is the bulk TDI residue fill area and lies underneath the Bayer Plant wastewater and storm water storage and treatment facilities. The existing facilities have either been constructed on or within fill material consisting of alluvial soils interspersed with TDI residues. The area of SWMU Group B is estimated to be approximately 10.5 acres. SWMU 5 currently contains an equalization basin, approximately 2 acres in area, and a rainwater storage lagoon, approximately 1.2 acres in area. The average depth of the basins is 20 feet. The existing Bayer Plant wastewater treatment facility includes two (2) 125-ft diameter clarifiers, two (2) 100-ft diameter aeration tanks, and other small support buildings.

The CAOs associated with SWMU Group B focus on prevention of on-site worker exposures to zones greater than 5 ft in depth and reduction of contaminant leaching to groundwater as part of the intermediate/long-term goal of improvement of groundwater quality.

SWMU GROUP C

SWMU Group C contains three relatively small areas (SWMUs 8, 9 and 11), and one large general residue fill area (SWMU 7). SWMUs 8 and 11 were former waste treatment pits, from 200-400 sf in area, ranging from 7-10 feet deep. SWMU 9 was a temporary residue storage pile area, approximately 100 by 140 feet. SWMUs 8, 9 and 11 appear to be in open, non-operations areas. SWMU 7 encompasses an approximately 4 acre area in Block 21 that includes the incinerator facilities, the fuel oil storage tank area and the other SWMUs of the group. The SWMU Group C Area has either been constructed on or within fill material consisting of alluvial soils interspersed with miscellaneous solid waste debris and TDI residues.

The CAOs associated with SWMU Group C focus on prevention of on-site worker exposures to zones greater than 5 ft in depth and reduction of contaminant leaching to groundwater as part of the intermediate/long-term goal of improvement of groundwater quality.

SWMU GROUP D

SWMU Group D encompasses the former wastewater trench (SWMU 10) and acid neutralization basin system. The trench was located in a former stream channel that run through the plant and was connected to the neutralization basins (SWMUs 12, 15 and 16). The trench segment identified as SWMU 10 contains a main branch approximately 1850 feet long, and a lateral section approximately 400 feet in length. SWMU 12 was reported to be 30 ft by 100 ft by 17 ft deep. SWMUs 15 and 16 are smaller, with dimensions of 10 ft by 30 ft and 12 ft by 12 ft by 15 ft, respectively. The depth of SWMU 15 is not known. Each of the basins were unlined pits used for acid wastewater neutralization. The trench and basins have all been backfilled.

The CAOs associated with SWMU Group D focus on prevention of on-site worker exposures to zones greater than 5 ft in depth (SWMUs 10 and 12 only), and reduction of contaminant leaching to groundwater as part of the intermediate/long-term goal of improvement of groundwater quality (SWMUs 10 and 12 only). SWMUs 15 and 16 were found to not present a risk to onsite workers since none of the soil samples in these areas exceeded the industrial RBCs. In addition, these SWMUs did not have any soil samples in exceedance of

EPA Region III SSLs, and therefore they are not considered as a potential source of contaminant leaching to groundwater.

SWMU 21

SWMU 21 is the former Nitrations Neutralization Basin 5Fc. This unit was used to treat wastewater from the Nitrations Process Area with limestone. The unit was an unlined earthen basin 30 ft by 30 ft in area. Depth is not known. Effluent was discharged to the main process trench.

The CAOs associated with SWMU 21 focus on prevention of on-site worker exposures to zones greater than 5 ft in depth, and reduction of contaminant leaching to groundwater as part of the intermediate/long-term goal of improvement of groundwater quality.

SWMU 27

SWMU 27 consists of two small areas, one located on the southeastern side of Block 27 and the other on the western side of Block 17. Two releases have been recorded in Blocks 17 and 27 from product pipelines. One release occurred on January 16, 1994 and consisted of approximately 400 pounds of benzene. The second release occurred on January 17, 1994 and consisted of approximately 150 pounds of benzene. The spilled material was collected and contaminated soils were containerized and shipped offsite for proper disposal.

The CAOs associated with SWMU 27 focus on prevention of on-site worker exposures to zones greater than 5 ft in depth, and reduction of contaminant leaching to groundwater as part of the intermediate/long-term goal of improvement.

SITE-WIDE GROUNDWATER

The Site-wide Groundwater alluvial aquifer is described in more detail in **Section 3.0 Summary of Current Conditions**. Based on a summary of all three phases of the RFI and a site-specific risk assessment incorporating the information from all three phases, the Phase III RFI drew the following conclusions relative to Site-wide Groundwater:

1. Site-wide Groundwater does not represent a current risk to human health or the environment and;
2. The existing Site-wide Groundwater recovery system provides hydraulic containment of the contaminated groundwater preventing off-site migration of dissolved phase COIs.

CAOs for Site-wide Groundwater are based on continued hydraulic containment of the contaminated groundwater (i.e. dissolved phase plume) over the short to long-term and the achievement of the following goals:

1. Prevent unacceptable human exposure to contaminated groundwater.
2. Control the migration of contaminated groundwater to a level that is protective of surface water quality.
3. Employ reasonable efforts to eliminate or mitigate further releases of contaminants from SWMUs (using the site boundary as the POC).
4. Reduce groundwater contaminant levels, as practicable, over time to support reasonably expected use.

As previously discussed, the current Site use-designation is industrial. This use-designation is anticipated to remain industrial for the foreseeable future (i.e. long-term >20 years).

Table 5-1 contains a list, along with brief descriptions, of the specific Corrective Action technologies that were considered for SWMU Group A, Main Plant SWMUs and Site-wide Groundwater. Bayer discussed each of these potential Corrective Action technologies with the regulatory agencies prior to finalization. Each potential Corrective Action technology from **Table 5-1** was screened against the screening criteria specified in the USEPA Corrective Action Plan Guidance Document, (USEPA, May, 1994) as follows:

- **Site Characteristics –** The Site's current status and conditions along with historical information was reviewed to identify Site characteristics that limit or promote the use of each technology. Technologies whose use is precluded by site characteristics were eliminated from further consideration.
- **Waste / Contaminant Characteristics –** The physical and chemical characteristics of the Site waste and COIs were assessed to determine if the potential Corrective Action technologies were appropriate. Technologies clearly limited in effectiveness by identified waste / contaminant characteristics were eliminated from further consideration.
- **Technology Limitations -** The status of technology development and performance experience with respect to Site COIs, constructability, and operation / maintenance issues were identified and evaluated for each of the potential Corrective Action technologies. Technologies that were deemed unreliable, perform poorly, or are not fully demonstrated were eliminated from consideration. Corrective Action technologies whose performance and effectiveness have been successfully demonstrated at other sites with similar COIs and site conditions will be given preference in the final recommended Corrective Measures.

Additionally, a fourth screen was added to assess the ability of each potential Corrective Action technology to achieve the Site CAOs related to that particular area (i.e. SWMU Group A, MPA or Site-wide Groundwater).

5.1 IDENTIFICATION OF POTENTIAL CORRECTIVE ACTION TECHNOLOGIES

Based on the initial screening criteria several potential Corrective Action technologies for SWMU Group A, the MPA and Groundwater Areas at the Site were retained for further evaluation. Those potential Corrective Action technologies retained through this initial screening criteria evaluation will be incorporated into a more detailed analysis of potential Corrective Action technologies for SWMU Group A, MPA and Site-wide Groundwater in Section 6.0 and assembled into Site Corrective Measures Alternatives and evaluated in Section 7.0.

Tables 5-1 presents a list and a description of the various technologies that were evaluated for potential use as components of a final Corrective Measure alternative. The results of this initial screening of potential Corrective Action technologies are detailed on a technology-by-technology basis in **Tables 5-2** through **Table 5-25**; summarized by area in **Table 5-22 (**SWMU Group A)**, Table 5-23** (MPA) and **Table 5-24** (Site-wide Groundwater); and summarized for the overall Site in **Table 5-25. Table 5-25** shows the potential Corrective Action technologies that have been retained for more detailed analysis in Section 6.0. All of the potential Corrective Action technologies were appropriate for at least one of the three screening criteria, but the final determination to retain a particular Corrective Action technology was based on all three of the screening criteria listed above as well the ability of the technology to assist in attainment of Site CAOs. The results presented in **Table 5-25** were previously presented and discussed with the regulatory agencies prior to finalization.

6.0 Evaluation and Selection of the Corrective Action Technologies

The purpose of this section is to evaluate the Corrective Action alternative technologies retained through the initial screening process completed in Section 5.0 for SWMU Group A, MPA SWMUs and Site-wide Groundwater.

6.1 Evaluation Criteria

Each technology retained for SWMU Group A, MPA SWMUs and Site-wide Groundwater will be evaluated with respect to the following seven (7) evaluation / balancing criteria: long term effectiveness; implementability; short-term effectiveness; toxicity, mobility and volume reduction; community acceptance; state acceptance and cost (Region III Model CMS Outline). The goal of this evaluation is to identify the best-balanced technology selections for SWMU Group A, MPA SWMUs and Site-wide Groundwater for inclusion into Site Corrective Measures Alternatives for evaluation in Section 7. Aspects of each technology addressed during the seven balancing criteria evaluation are further defined as follows:

6.1.1 Long-Term Effectiveness

- Assessment of the expected effectiveness after the technology is in place and for a minimum of 30 years thereafter.
- The degree of certainty that the technology will attain and continue to meet Site CAOs.
- Projected useful life, and the degree of operation and maintenance required.
- Potential risks from hazardous constituents.
- Reliability.

6.1.2 Reduction of Toxicity, Mobility or Volume

- Ability to reduce the toxicity, mobility and volume of COIs (EPA's preference). Those technologies assessed to be capable of eliminating or substantially reducing the toxicity, mobility or volume were scored higher.
- The potential for the technology to produce adverse side effects such as new COIs from residual by-products.

6.1.3 Short-Term Effectiveness

- Potential risks to workers, the surrounding community, or the environment that may be encountered during the implementation (i.e. fire, explosion, structural integrity of existing operations).
- Potential threats associated with treatment, excavation, transportation and re-disposal, or containment of waste material.
- Capability to achieve the short-term CAOs.

6.1.4 IMPLEMENTABILITY

- Ease or difficulty to implement.
- Feasibility of constructing, operating and monitoring the technology in view of site specific issues.
- Length of time and likelihood of successfully acquiring all necessary permits and off-site approvals.
- Availability at the Site of other services and materials needed to implement the technology (i.e. waste treatment, storage and disposal services).
- Time required for design, construction and implementation.

6.1.5 COSTS

- Direct (materials, labor, equipment, land and site development expenses, and building and service costs) and indirect capital costs (engineering expenses, legal fees, license or permit fees, startup and shakedown costs, and contingency allowances).
- Long-term operation and maintenance (O&M). These include: operating labor costs; maintenance materials; maintenance labor costs; sampling and laboratory fees; disposal and treatment costs; regular reporting costs; insurance; and contingency funds.
- Monitoring costs necessary to maintain the continued effectiveness of the evaluated Corrective Action.
- Thirty-year present worth calculations for constant dollar (2006) comparisons *(discount factor of 5*% was used). Technologies with a present worth 100% greater than alternatives that offer comparable benefits were eliminated.

Cost estimates were developed using Construction Link, Inc. [CLI] software. A baseline generic cost estimate was prepared using CLI for each technology and included all typical construction (capital) costs. Because of the similarity in some Site SWMUs, the baseline estimates were used to estimate certain other SWMU costs by scaling up or down based on relative quantities. Economies of scale factors were also applied when a specific SWMU quantity was significantly different than the baseline quantity. The baseline and scaled cost estimates and their scaling factors are summarized on the cost backup tables in **Appendix A**. Bayer provided unit costs for technologies that involved on-site treatment, including wastewater treatment and incineration. The costs were then summarized in a series of tables for each of the SWMU / SWMU Groups and Site-wide Groundwater.

6.1.6 COMMUNITY ACCEPTANCE

- Potential for the local community to have any concerns or objections with any aspect of a particular Corrective Action technology.

6.1.7 STATE ACCEPTANCE

- Potential for acceptance by WVDEP.

- Potential for compliance with applicable State and Federal regulations (including permits, reporting requirements, etc.) that may be necessary prerequisites to implementation of a technology.

6.1.8 Corrective Action Technology Balancing Criteria Evaluation Methodology

Corrective Action technology alternatives have been numerically evaluated based on best professional judgment and experience with these technologies and application to Site conditions. Each of the potential Corrective Action technologies that were retained after the initial screening in Section 5.0 for SWMU Group A, Main Plant Area SWMUs and Site-wide Groundwater have been scored pursuant to each of the seven evaluation criteria. The evaluation methodology is defined in the table below. Numerical values ranging from “0” to “2” were assigned to each of the seven balancing evaluation criteria for each technology - dependent on the assessed ability of that technology to address that specific evaluation criterion. For example, if a technology is judged to have a “moderate” ability to meet the Long-term Effectiveness criterion relative to the alternative technologies being considered, that technology was given a score of 1 for that criterion.

Corrective Action Technology Evaluation Methodology

Evaluation Criterion	Qualitative Description	Numerical Value
Long-term Effectiveness	Limited to none	0
	Moderate	1
	Effective	2
Reduction of Toxicity, Mobility or Volume	Limited to None	0
	Moderate	1
	Effective	2
Short-term Effectiveness	Limited to none	0
	Moderate	1
	Effective	2
Implementability	Easy	2
	Moderate	1
	Difficult	0
Costs	Minimal	2
	Moderate to Low	1
	High	0
Community Acceptance	Low	0
	Moderate	1
	High	2
State Acceptance	Low	0
	Moderate	1
	High	2

The scores for the individual seven (7) balancing criteria for each technology were summed to determine the overall technology score for each potential Corrective Action technology for SMWU Group A, Main Plant Area SWMUs and Site-wide Groundwater.

In the comparison of the seven (7) criteria, overall cost evaluations, using present value costs, are also as part of the final recommendation process. These costs account for the non-discounted direct/indirect (capital) costs, O&M (annual) costs, and associated periodic costs for each of the evaluated Corrective Action technologies. A comparative summary of present value costs is presented at the end of the evaluation for SMWU Group A, Main Plant Area SWMUs and Site-wide Groundwater.

6.2 SWMU GROUP A- SOUTH LANDFILL AREA- SWMUS 1, 2, 3 AND 4

As described in detail in **Section 5.0**, SWMU Group A contains the South Landfill (SWMU 1) and associated waste management areas: Sludge Lagoon (SWMU 2), Hydroblasting Station (SWMU 3) and the Ash Lagoon (SWMU 4). SWMU Group A is entirely within the property boundary of the Site, which has controlled access. SWMU Group A is estimated to be approximately 7 acres. See **Figure 3-1** for location within the Site.

The technologies identified for SWMU Group A that could potentially attain the CAOs, either as standalone or in combination, that remained after the **Section 5.0** screening step are summarized in **Table 5-22**, and shown below:

SWMU Group A Technology Screening Summary	
Technology	***Screening Result***
Institutional Controls	**Retained**
Covers/Caps (Soil, pavement and/or synthetic membranes)	**Retained**
Containment Barriers (Sheet piles, slurry walls, synthetic membranes)	**Retained**
Passive Treatment Walls [Vertical walls constructed by trenching and/or injection.]	
Zero-valent iron (ZVI)	**Retained**
Biosparging	**Retained**
In-Situ Treatment	
In-situ Chemical Oxidation (ISCO)	**Retained**
In-situ Biological (ISB) [Aerobic and/or Anaerobic]	
Chemical Flushing	
Soil Vapor Extraction (SVE)	
Enhanced SVE (In-situ thermal desorption by resistance and/or RF heating)	
Stabilization	**Retained**
Ex-Situ Treatment/Disposal [Assumes removal by excavation and/or pumping]	
On-site Incineration (Bayer Facility)	**Retained**
Off-site Incineration	**Retained**
Thermal Desorption	
Biopiles / Landfarming	
Soil Washing	
Off-site Landfill	**Retained**
Groundwater Treatment	
Site-wide Groundwater Containment and Treatment	**Retained**
Natural Attenuation	
Trenches and/or recovery wells (SWMU Group A perched water)	**Retained**

The **Section 5.0** screening process resulted in twelve potential technologies which were assessed capable of meeting Site CAOs associated with SWMU Group A. A review of Site CAOs as they apply to SMWU Group A will provide focus to this detailed balancing evaluation of the twelve technologies. The RFI, summarized in **Section 3.0 Summary of Current Conditions**, concluded that Site areas requiring further study pursuant to this CMS are:

- SWMU Groups A, B, C and D; SWMU 21; and SWMU 27, relative to the potential to leach COIs from the SWMU into Site Groundwater at concentrations of potential concern;
- Site Groundwater

As described in detail in **Section 4.0 Correction Action Objectives**, the CAOs (general descriptions of what Corrective Measures are intended to accomplish) for the Site, address two environmental media, soils and groundwater, or more specifically:

- SWMU Group A related Site Soils, relative to the potential to leach COIs into Site Groundwater at concentrations of potential concern.
- SWMU Group A groundwater as it relates to Site-wide Groundwater.

The overall CAO for SWMU Group A is:

- At all times, prevent unacceptable human exposure from affected SWMU Group A Groundwater and Site Soils

The SWMU Group A Soil CAOs are therefore:

- Prevent unacceptable industrial worker exposures to SWMU Group A shallow (0 to 2 ft-bgs) surficial soil COIs (i.e. detected contaminants),
- Prevent unacceptable construction worker exposures to SWMU Group A subsurface (0 to 5 ft-bgs) soil COIs, and
- Prevent unacceptable construction worker exposures to SWMU Group A soil COIs (at all depths).

The SWMU Group A groundwater CAOs are:

- Prevent unacceptable human exposures to recovered contaminated groundwater from SWMU Group A.
- Maintain current plume hydraulic containment of SWMU Group A within the Site boundary.
- Provide for the continued control of potential off-site migration of contaminated groundwater from SWMU Group A to a level that is protective of surface water quality.
- Implement reasonable efforts to eliminate or mitigate further releases of contaminants from SWMU Group A (using the site boundary as the point of compliance).

An evaluation of the twelve potential technologies with respect to their ability to achieve these SWMU Group A CAOs follows.

6.2.1 INSTITUTIONAL CONTROLS

6.2.1.1 DESCRIPTION

Institutional controls (ICs) for SWMU Group A are designed to prevent human exposures to soil and groundwater contaminants over both the short and long-term periods. Potential exposures in the short-term would be to onsite workers (industrial and construction) who may excavate in areas with soils or groundwater with elevated COIs at depths beyond 5 feet. Long-term potential exposures will be the same, based on the premise that the Site future site will remain industrial.

Potential ICs include the following:

- Plant safety plan with descriptions of the contaminants and safety protocols and restrictions for working within or near SWMU Group A.
- Hazard communication plan for worker activities potentially exposed to SWMU Group A, including periodic worker and contractor training as necessary, with a general plant facility plan and mapping notations for SWMU conditions for reference purposes.
- Physical identification (signs) and fencing, if appropriate.
- Deed restrictions and/or recordation with Miss Utility of West Virginia. Deed restrictions will run with the title to the land.
- Groundwater monitoring.

The evaluation of Institutional Controls against the seven balancing criteria follows, with the score for each criterion in parentheses.

6.2.1.2 LONG-TERM EFFECTIVENESS (Effective -2)

- Effective in limiting the unacceptable worker exposures to subsurface contaminants. The local population is prevented from potential exposures by continuous fencing around the plant and controlled access and security.
- Dependent on the maintenance of the plant safety, security and training programs.
- Subsurface contaminant levels will not be reduced.
- Deed restrictions will provide for long-term protection. Communication and enforcement is an administrative concern as a standalone Corrective Action.
- Will meet or assist in meeting all SWMU Group A related CAOs except for some related to groundwater:
  - Maintain current plume hydraulic containment of SWMU Group A within the Site boundary.
  - Provide for the continued control of potential off-site migration of contaminated groundwater from SWMU Group A to a level that is protective of surface water quality.

- o Implement reasonable efforts to eliminate or mitigate further releases of contaminants from SWMU Group A (using the site boundary as the point of compliance).

6.2.1.3 REDUCTION OF TOXICITY, MOBILITY OR VOLUME (None – 0)

- ➢ Will not reduce or eliminate the toxicity or mass of COIs.

6.2.1.4 SHORT-TERM EFFECTIVENESS (Effective – 2)

- ➢ Immediate in limiting exposure risk to the SWMU Group A

6.2.1.5 IMPLEMENTABILITY (Easy – 2)

- ➢ Implementable within the current safety and operating protocols at the plant.

6.2.1.6 COSTS (Minimal– 2)

Major cost components for ICs include: Safety Plan engineering; Physical barriers (fencing, signs and notifications); and an assumed eight (8) groundwater monitoring wells. Long-term O&M costs assuming thirty (30) years of O&M have also been estimated. The engineering cost estimate summary for the ICs is presented in **Table 6.2-1**.

6.2.1.7 COMMUNITY ACCEPTANCE (High – 2)

- ➢ No concerns or objections expected

6.2.1.8 STATE ACCEPTANCE (High – 2)

- ➢ No concerns expected when used in conjunction with other Corrective Action technologies.

6.2.1.9 SWMU GROUP A- INSTITUTIONAL CONTROLS EVALUATION SUMMARY

ICs are intended for use in conjunction with other Corrective Action technologies and not as a standalone technology. ICs are therefore selected for further evaluation as an element of a SWMU Group A Corrective Measure alternative.

Long-term Effectiveness	Reduction of Toxicity, Mobility or Volume	Short-term Effectiveness	Implementability	Costs	Community Acceptance	State Acceptance	Overall Numerical Ranking	Selected for SWMU or SWMU Group
Effective 2	None 0	Effective 2	Easy 2	Minimal 2	High 2	High 2	12	Yes

6.2.2 Caps/Covers

6.2.2.1 Description

The cap/cover Corrective Action technology for SWMU Group A consists of either a soil cover or a synthetic CAP over the approximate 7-acre area of SWMU Group A. For purposes of this evaluation, this technology is assumed to incorporate the following:

- Ash lagoon backfill to achieve sloped subgrade (min. 2%) , approximately 2,000 cy
- Site grading to achieve min. 2% grade (avg. 1 ft thick over 7 acres- 11,000 cy)
- Geotextile base (non-woven), HDPE membrane (80-mil), geosynthetic drainage net and final cover soil (2 ft thick) and vegetation,
- Groundwater monitoring (four wells). (A detailed evaluation will be conducted on Site monitoring well requirements, incorporating the location of the existing monitoring wells and determining the need for, and optimal location of, any additional monitoring wells that may be needed.)

Other capping technologies, such as low-permeability clay soil barriers, may be appropriate for prevention of worker exposures and reduction of infiltration. Asphalt, concrete and other rigid-pavement caps are not considered feasible because of the expected long-term settlement of the waste fill and the associated cracking/failure of the cap layer. Supplemental dewatering/stabilization of the ash is not included in the corrective measure, although this action may be necessary if the ash fill does not have sufficient strength to support heavy equipment and the cap material.

The evaluation of Caps/Covers is described in the following sections.

6.2.2.2 Long-term Effectiveness (Moderate – 1)

- ➢ Moderate improvement in meeting CAOs for Site Groundwater vs. current operation of pump and treatment and containment of Site Groundwater.
- ➢ Site-wide Groundwater may be positively affected. The CAP would be effective in eliminating precipitation infiltration, thus isolating the existing waste materials and high concentration soils that are potentially leaching contaminants to the groundwater, and potentially reducing the overall contaminant loading. Groundwater quality improvements would be realized by any reduction of contaminant leaching to groundwater. A cap alone will not prevent groundwater migrating in the alluvial aquifer from leaching waste materials that are present below the water table. Note that at the time of placement, these wastes were not put into the water table, but rather the water table rose into the waste material after the installation of the Hannibal Dam and subsequent rise in the Ohio River stage.
- ➢ Viable long-term with ongoing inspection and maintenance.

- Would assist in further limiting worker exposure potential to subsurface contaminants.
- Limits the potential for leaching of COIs to surface / subsurface soils.
- Effectiveness will be difficult to measure. Monitoring of groundwater quality in the alluvial aquifer at SWMU Group A may not be an effective measurement of the effects of a Corrective Action due to the historic co-mingling of plumes from other Site SWMUs.

6.2.2.3 REDUCTION OF TOXICITY, MOBILITY OR VOLUME (Limited-0)

- No reduction in toxicity or volume of waste (& COIs)
- Mobility of the COIs minimized through reduced leaching.

6.2.2.4 SHORT-TERM EFFECTIVENESS (Limited – 0)

- Increased potential for construction worker exposure during installation.
- No improvement in the landfill vs. current soil cover in combination with ICs.

6.2.2.5 IMPLEMENTABILITY (MODERATE – 1)

- Conventional technology but may have some constructability issues (subsidence, etc.) in placement of a cap/cover. Waste material has been infiltrated by the engineered increase in the water table (Ohio River level increase) leading to a greater potential for subsidence.
- Underground piping and utilities that would be covered by the cap would need to be relocated for future access.

6.2.2.6 COSTS (MODERATE – 1)

The engineering cost estimate summary for the cap/cover Corrective Action technology is presented in **Table 6.2-2**. Groundwater monitoring will be a required component of this technology and existing or new monitoring wells will be required to provide for long-term monitoring of SWMU Group A. Major cost component assumptions for this technology include:

- Construction management (@ 8% capital costs),
- Ash lagoon backfill to achieve sloped subgrade (min. 2%), approximately 2,000 cy,
- Site grading to achieve min. 2% grade (avg. 1 ft thick over 7 acres- 11,000 cy),
- Engineered Cap / cover. The following assumptions have been made for cost estimation purposes: Geotextile base (non-woven), HDPE membrane (80-mil), geosynthetic drainage net, final cover soil (2 ft thick) and vegetation,
- Up to four (4) additional monitoring wells in the alluvial aquifer, located at the POC (Site boundary).

- Long-term O&M costs assuming thirty (30) years of O&M have also been estimated for the implementation of this Corrective Action technology. Annual and periodic costs include:
    - Cap maintenance and replacement (@ 2% capital cost/year),
    - Annual groundwater monitoring (VOCs, SVOCs, metals),
    - Annual data evaluation and reporting,
    - Monitoring well replacement (20% every 5 years)

6.2.2.7 COMMUNITY ACCEPTANCE (HIGH – 2)

➢ No concerns or objections expected.

6.2.2.8 STATE ACCEPTANCE (HIGH – 2)

➢ No concerns or objections expected.

➢ Consistent with Regulatory considerations.

6.2.2.9 SWMU GROUP A- CAPS/COVERS EVALUATION SUMMARY

Caps / Covers overall score as a standalone technology is 7:

Long-term Effectiveness	Reduction of Toxicity, Mobility or Volume	Short-term Effectiveness	Implementability	Costs	Community Acceptance	State Acceptance	Overall Numerical Ranking	Selected for SWMU or SWMU Group
Moderate 1	Limited 0	Limited 0	Moderate 1	Moderate 1	High 2	High 2	**7**	**Yes**

6.2.3 CONTAINMENT BARRIERS- STEEL SHEETING

6.2.3.1 DESCRIPTION

Containment barriers are designed to reduce lateral hydraulic loading and the associated potential for the lateral migration of the groundwater to solubilize and transport dissolved phase COIs. Currently, groundwater from the SWMU Group A that may contact COIs is contained by the site-wide groundwater recovery well system (MFG, 2003). The containment barrier would be designed to further isolate SWMU Group A groundwater from the Site-wide Groundwater.

Containment barriers may be used in conjunction with caps/covers (Section 6.2.2) to provide isolation of a waste area. Groundwater dewatering and treatment (in existing Bayer wastewater treatment plant) and monitoring are included in this alternative. Four (4) new monitoring wells in the alluvial aquifer at the POC are also included for cost estimate purposes. A detailed evaluation will be conducted on Site monitoring well requirements, incorporating the location of the existing monitoring wells and determining the need for, and optimal location of, any additional monitoring wells that may be needed.

The barrier technology evaluated for SWMU Group A includes a vertical containment barrier in the form of steel sheet piling installed to depths of ~50-60 ft-bgs and tied to bedrock. This concept isolates the area within SWMU Group A from the associated underlying groundwater zone. Conventional steel sheeting with field-applied joint sealant (Adeka epoxy or equivalent) is included to minimize the wall hydraulic conductivity. The area within SWMU Group A requiring the containment barrier is estimated to cover approximately 7-acres and the containment barrier would extend over a lineal distance of approximately 2500 ft.

The depth of installation would be relatively deep (~60 feet). Driving long steel sheet piling through the anticipated alluvial strata is a significant concern. Published literature indicates that the estimated minimum wall modulus for the anticipated subsurface conditions is approximately 55 in^3/ft (e.g., min. AZ34 or PZ40) for low-yield steel and 50 in^3/ft (e.g., min. AZ28, PZ40) for high-yield steel. Test driving is recommended. Discussions with a local contractor indicated a similar wall modulus value and a similar concern with driving through the alluvial layer.

6.2.3.1.1 Containment Barrier Hydrologic Analyses

A hydrologic analysis has been made to estimate the net water inflow to the containment cell for the purposes of costing dewatering and water treatment measures. The main components of inflow to the containment cell area are: rainfall infiltration, barrier leakage and bedrock leakage. The SWMU Group A containment area total seepage rates are estimated to range from 8 to 19 gpm. Groundwater removal from within the containment barrier is included in this measure. The level of internal drawdown is estimated to be at elevation 600 ft (H2) to maintain an inward hydraulic gradient and also to dewater the waste fill area. This will result in a higher maintenance dewatering rate. Additional recovery wells within the containment barrier are included in this measure for this purpose.

It is also assumed that the existing groundwater removal/treatment system will be in operation and will allow treatment of pumped groundwater, and also contain any groundwater constituents that may migrate outward through the containment barrier. This alternative will include the *incremental costs* for treating the total estimated seepage through the containment system. This seepage (and average pumping rate) is estimated at 38 gpm (19 gpm x 2.0 safety factor) for cost evaluation purposes.

6.2.3.1.2 Barrier Constructability

The choice of a suitable driving system is of fundamental importance to ensure successful pile installation. Diesel hammers perform especially well in cohesive or very dense soil strata. Under normal conditions it is usual to select a ratio of ram weight to weight of pile plus cap of 1:2 to 1.5:1. A driving cap with a dolly is necessary to protect the pile heads and hammer during driving. A penetration of 1-in per 10-blows should be considered as the limit for the use of diesel hammers. However, one contractor did indicate that they would first consider a vibro-hammer or possibly a hydraulic press. It should be noted that vibratory pile drivers are best suited for work in non-cohesive soils especially when they are water-saturated.

In the anticipated difficult soil conditions of this site with regard to pile installation, sheet pile placement should involve panel installation combined with staggered driving. Piles should be installed between guide frames and driven in short steps: piles 1, 3 and 5 first, then 2 and 4, etc. Reinforcement at the tips is prudent for piles 1, 3 and 5. Intermediate guides are recommended to prevent flexing and other associated driving problems. Another method to improve drivability includes pre-drilling small diameter holes which have the effect of reducing the resistance of the soil strata, but can also provide a conduit for seepage. High pressure jetting is another option, but both options may be precluded due to the contaminants at the project site.

Appropriate precautions should also be taken to determine if the sheeting "unzips" during hard driving (e.g., signal transmitters, etc.) and contingency plans should developed to handle construction problems, such as refusal above minimum tip elevation, etc. Driving alone through the anticipated soil profile will most likely not achieve 100% penetration of all sheeting into the rock. Subsurface unzipping would result in significant increased lateral leakage through the barrier. This condition was not factored into the barrier leakage calculation.

Test driving that demonstrates unsatisfactory placement of the steel sheeting may necessitate the selection of an alternative barrier technology that involves trench excavation, such as a slurry wall. A cap/cover and internal groundwater recovery wells would be required in conjunction with the barrier to reduce/eliminate the infiltration of water and maintain an inward groundwater hydraulic gradient within the barrier system.

The evaluation of Containment Barriers is described in the following sections.

6.2.3.2 LONG-TERM EFFECTIVENESS (MODERATE – 1)

- Effective in isolating the waste material and high concentration soils from groundwater, potentially reducing the overall loading of COIs to groundwater from leaching.
- The degree of seepage reduction is dependent on the constructability of the sheet pile wall to the extent that the integrity of the seams is compromised.
- No reduction in long-term risks to human health and the environment from current levels as the COIs will be left in place.
- ICs still needed to limit future exposure risks.

6.2.3.3 REDUCTION OF TOXICITY, MOBILITY OR VOLUME (LIMITED – 0)

- No reduction in toxicity or volume of COIs with the barrier system alone. Provides second line of defense (i.e. in addition to Site-wide Groundwater hydraulic containment) against the potential for SWMU Group A COIs to be transported to surface water.

6.2.3.4 SHORT-TERM EFFECTIVENESS (LIMITED – 0)

- Increased potential short-term exposure risk for construction workers.
- No improvement in meeting Short-term CAOs vs. current actions.

6.2.3.5 IMPLEMENTABILITY (DIFFICULT – 0)

- Difficult construction techniques given the subsurface geological conditions and depth to bedrock. Test driving that demonstrates unsatisfactory placement of the steel sheeting may necessitate the selection of an alternative barrier technology that involves trench excavation, such as a slurry wall. (see Section 6.2.3.1.2 on constructability).
- Site utilities and process piping in the general alignment of the barrier wall will be difficult to relocate.

6.2.3.6 COSTS (HIGH – 0)

Costs are high ($8.8MM Capital cost) with a high level of uncertainty. The engineering cost estimate summary for the containment barrier Corrective Action technology is presented in **Table 6.2-3**.

Direct and indirect capital costs and required groundwater monitoring component costs have been estimated using the following assumptions:

- Construction management (@ 8% capital costs),
- Site grading to provide working platform for sheeting installation,
- Steel sheeting placement (AZ-34 low-yield steel sheet, 140,000 sf),

- o Assumed four (4) dewatering wells in the alluvial aquifer, inside of the containment system,
- o Water pipeline additions from SWMU GROUP A recovery wells to plant wastewater treatment system,
- o Groundwater treatment of incremental additional flow of 38 gpm (costs under O&M, Section 6.2.3.6.2), and
- o Four (4) new monitoring wells in the alluvial aquifer at the POC.

Long-term O&M costs ($75,000 annually) assuming thirty (30) years of O&M have been estimated.

- o Annual groundwater monitoring (VOCs, SVOCs, metals),
- o Annual data evaluation and reporting,
- o Monitoring well replacement (20%/5 years),
- o Recovery well operation (@ 5% capital costs/yr),
- o Groundwater treatment (38 gpm @ $1.00/1000 gallons)

6.2.3.7 COMMUNITY ACCEPTANCE (HIGH – 2)

- ➢ No problems or concerns are expected.

6.2.3.8 STATE ACCEPTANCE (HIGH – 2)

- ➢ State/agency acceptance is expected.

6.2.3.9 SWMU GROUP A- SHEET PILE CONTAINMENT BARRIER EVALUATION SUMMARY

Steel sheet pile containment barriers were evaluated for the seven criteria and were scored based on the evaluation. Sheet Pile Containment is not selected for further consideration primarily because of limited improvement in meeting CAOs, implementability concerns coupled with high costs. The evaluation results are summarized below:

Long-term Effectiveness	Reduction of Toxicity, Mobility or Volume	Short-term Effectiveness	Implementability	Costs	Community Acceptance	State Acceptance	Overall Numerical Ranking	Selected for SWMU or SWMU Group
Moderate 1	Limited 0	Limited 0	Difficult 0	High 0	High 2	High 2	**5**	**No**

6.2.4 CONTAINMENT BARRIERS- SLURRY WALL

6.2.4.1 DESCRIPTION

Analogous to a sheet pile, the purpose of a slurry wall is to isolate sources of COIs from the associated groundwater zone beneath the source, reduce lateral hydraulic loading, and reduce or eliminate the lateral migration potential of COIs into the groundwater.

The barrier technology evaluated for SWMU Group A consists of a soil-bentonite slurry wall installed to depths commensurate with the bottom of the alluvial aquifer (~50-60 ft-bgs to bedrock). The slurry wall is constructed by excavating a trench that is filled with a bentonite slurry. The slurry hydraulically supports the trench to prevent collapse and forms a filter cake on the trench walls to reduce groundwater flow. The trench is backfilled with the excavation spoils that are blended with additional bentonite to form the complete barrier wall. If the excavated spoils are not free of contaminants, they would not be useable for a trench backfill. Clean fill material would need to be imported for backfill, and the spoils would be assumed to be placed onsite within the limits of SWMU Group A. For costing purposes, it is assumed that imported backfill material for SWMU Group A will not be needed.

The area within SWMU Group A requiring the slurry wall barrier is estimated to cover approximately 7-acres and the wall length is estimated to be approximately 2500 lineal ft (see **Figure 3-1**). For a maximum barrier depth of ~60 feet, the wall could be constructed with a large excavator. These excavators have been used for trenches up to 100 feet in depth. A working platform approximately 50-100 feet wide is required for trench construction. The irregular topography surrounding SWMU Group A makes it impractical to grade the wall alignment level or to a gentle slope around the entire perimeter. This surface topography would necessitate that the wall be constructed in stepped sections. Transitions between the sections could be constructed with clay fill, injected grout walls, or steel sheeting. Support facilities would include water and bentonite storage systems, a slurry mix plant and a materials unloading area. These facilities would most likely be located in a temporary support zone on top of the south landfill.

6.2.4.1.1 Containment Barrier Hydrologic Analyses

A hydrologic analysis has been made to estimate the net water inflow to the containment cell for the purposes of costing dewatering and water treatment measures. The main components of inflow to the containment cell area are: rainfall infiltration, barrier leakage and bedrock leakage. The SWMU Group A containment area total seepage rates are estimated to range from 18 to 33.5 gpm. Groundwater removal from within the containment barrier is included in this measure. The level of internal drawdown is estimated to be at elevation 600 ft (H2) to maintain an inward hydraulic gradient and also to dewater the waste fill area. This will result in a higher maintenance dewatering rate. Additional recovery wells within the containment barrier are included in this measure for this purpose.

It is also assumed that the existing groundwater removal/treatment system will be in operation and will allow treatment of pumped groundwater, and also contain any groundwater constituents that may migrate outward through the containment barrier. This alternative will include the *incremental costs* for treating the total estimated seepage through the containment system. This seepage (and average pumping rate) is estimated at 38.6 gpm (25.75 gpm x 1.5 safety factor) for cost evaluation purposes.

The evaluation of Containment Barriers is described in the following sections.

6.2.4.2 **LONG-TERM EFFECTIVENESS** (Moderate – 1)

Similar to sheet-pile barrier:

- Effective in combination with a cap/cover, in isolating the waste material and high concentration soils from groundwater, potentially reducing the overall loading of COIs to groundwater from leaching. The slurry wall is expected to provide greater actual seepage reduction than a sheet pile barrier, although theoretically the steel sheeting barrier would indicate a lower leakage rate.
- Weathered bedrock beneath the alluvium will not provide an impermeable zone to allow sealing of the containment barrier. The degree of seepage reduction will also depend on the constructability of the slurry wall.
- Uncertainty associated with the soil-bentonite compatibility with the site contaminants, especially volatile organics.
    - Research to-date has indicated that some organic contaminants can cause significant changes to clay structures and result in increased permeation to contaminants. Bench-scale compatibility testing with actual site contaminants is required to assess organic solvent permeability effects on the bentonite matrix and provide data to verify slurry wall feasibility and design the slurry mix. Other backfill compositions may need to be considered, including soil-attapulgite and geomembranes.
- No reduction in long-term risks to human health and the environment from current levels as the COIs will be left in place.
- Additional recovery wells would be required to manage barrier seepage within the containment area to maintain an inward hydraulic gradient.
- ICs needed to limit future exposure risks.

6.2.4.3 **REDUCTION OF TOXICITY, MOBILITY OR VOLUME** (Limited – 0)

Similar to Sheet pile barrier:

- Adds a second defense – in addition groundwater hydraulic containment – against the potential for COIs to be transported to surface water.

- No reduction in toxicity or volume of COIs.
- Pumping of groundwater from within the containment system will reduce the overall mass of contaminants.

6.2.4.4 SHORT-TERM EFFECTIVENESS (Limited – 0)

- Increased potential short-term exposure risk for construction workers.
- Increased potential exposures to site personnel and the community from trench excavation of significant quantities of subsurface materials, some of which is likely to be contaminated.
- No improvement in meeting Short-term CAOs vs. current actions

6.2.4.5 IMPLEMENTABILITY (Difficult – 0)

- Some similar issued to sheet pile:
    - Slurry wall construction subject to the presence of potentially difficult site surface conditions.
    - Any site utilities and process piping in the general alignment of the barrier wall would need to be relocated prior to implementation of this measure.
    - Property access along the western side of the barrier may need to be evaluated, depending on the final alignment of the wall with respect to the railroad right-of-way.
- Conventional construction equipment and the materials of construction are readily obtainable.
- Limited working area along the entire alignment, especially to the west.
- Varying topography along the alignment requires construction in stepped sections, resulting in additional excavation and grading to prepare the work areas. Transition zones between the sections would also entail additional work.
- Potentially unstable soil/waste zones (sludges and ash) with elevated groundwater will require the application of a heavy slurry mix to prevent trench failure. Some areas of the trench may fail because of these conditions, which would necessitate additional excavations. If subsurface conditions are found to be very unstable along sections of the proposed wall alignment, then pre-excavation measures, such as deep soil mixing stabilization, should be considered to allow maintenance of a stable excavation for the barrier. Pre-design investigations should be performed to establish subsurface conditions along the proposed wall alignment.

6.2.4.6 COSTS (Moderate – 1)

Costs are lower than sheet pile with similarly high uncertainty based on uncertainty of subsurface conditions, compatibility, etc. The engineering cost estimate summary for the slurry wall containment barrier Corrective Action technology is presented in **Table 6.2-4**.

Direct and indirect capital costs ($2.7 MM) and required groundwater monitoring component costs have been estimated using the following assumptions:

- Construction management (@ 8% capital costs),
- Site grading to provide working platform for wall installation,
- Soil-bentonite slurry wall (140,000 sf)
- 15,000 cy of spoil materials are assumed to be contaminated and placed within the SWMU GROUP A area for final disposal under the future cap/cover,
- Assumed four (4) dewatering wells in the alluvial aquifer, inside of the containment system.
- Water pipeline additions from SWMU Group A recovery wells to plant wastewater treatment system,
- Groundwater treatment of incremental additional flow of 38 gpm (costs under O&M, Section 6.2.3.6.2), and
- Four (4) new monitoring wells in the alluvial aquifer at the POC.

Long-term O&M costs ($61K annually) assuming thirty (30) years of O&M have been estimated. These costs would be realized mainly on the cap/cover portion of the alternative and groundwater collection, treatment and monitoring. Costs for Caps/Covers are addressed in Section 6.2.2.

- Annual groundwater monitoring (VOCs, SVOCs, metals),
- Annual data evaluation and reporting,
- Monitoring well replacement (20%/5 years),
- Recovery well operation (@ 5% capital costs/yr),
- Groundwater treatment (38 gpm @ $1.00/1000 gallons)

6.2.4.7 COMMUNITY ACCEPTANCE (HIGH – 2)

- No problems or concerns are expected.

6.2.4.8 STATE ACCEPTANCE (HIGH – 2)

- State/agency acceptance is expected.

6.2.4.9 SWMU GROUP A- SLURRY WALL CONTAINMENT BARRIER EVALUATION SUMMARY

Slurry wall barriers were evaluated for the seven criteria and were scored based on the evaluation. The slurry wall barrier is selected for additional evaluation based primarily on the more moderate costs vs. a sheet pile and comparable effectiveness.

The evaluation results are summarized below:

Long-term Effectiveness	Reduction of Toxicity, Mobility or Volume	Short-term Effectiveness	Implementability	Costs	Community Acceptance	State Acceptance	Overall Numerical Ranking	Selected for SWMU or SWMU Group
Moderate 1	Limited 0	Limited 0	Difficult 0	Moderate 1	High 2	High 2	6	Yes

There are other techniques and technology variations that are equally effective to physical barriers for preventing contamination of uncontaminated groundwater where wastes remain in place in the saturated zone, as is the case for SWMU Group A. As more fully described in Pump and Treat Groundwater Remediation, A Guide for Decision Makers and Practitioners (EPA/625R-95/005), "…hydraulic containment can be accomplished by controlling the direction of groundwater flow with capture zones or pressure ridges or physical barriers." These containment technology variations are not addressed in detail at this stage of the CMS.

6.2.5 PERMEABLE REACTIVE BARRIERS (ZERO VALENT IRON)

6.2.5.1 DESCRIPTION

A passive permeable reactive barrier (PRB) system for SWMU Group A has been assessed to be a potentially applicable Corrective Action technology for perched water. Implementation would involve the interception and in-situ treatment of perched water by use of a reactive media placed in a vertical wall configuration. Contaminated water is treated within the media and discharges from the wall under "natural" flow conditions. The "funnel and gate" application, where the PRB is installed in combination with a containment barrier (sheet pile or slurry wall) to hydraulically direct flow to the permeable wall "gate" is not considered applicable for SWMU Group A since a continuous low permeability layer (aquitard) is not present in the SWMU Group A area. The funnel and gate PRB is likely to alter the groundwater hydraulic regime and cause an increase in the water table elevation. The absence of the aquitard limits the vertical containment ability of the system and may result in an increased vertical migration of perched water to the alluvial aquifer.

For the CMS, a PRB system using zero-valent iron (ZVI) media is being evaluated. The barrier would consist of iron granules (ZVI) that are mixed with a porous fill, such as sand, and placed in a continuous trench across the horizontal path of the perched water. Other potential PRB media may also be applicable, including organic media (HUMASORB-CS, surfactant-modified zeolite (SMZ), nano-ZVI (submicron size), etc). The most cost-effective barrier media, and the site-specific barrier design for the final selected media, will require bench-scale testing with actual perched water.

PRB ZVI technology has been shown to be effective in treating VOCs and other organics present in SWMU Group A perched water. Chlorinated VOCs degradation by reductive dehalogenation and aromatics (benzene) destruction have been well established in the literature (USEPA, September, 1988; FRTR, December, 2002). Generally, chlorinated VOCs are readily reduced to non-toxic ethane, ethane and chlorides. Case studies of nitroaromatic degradation by ZVI are less commonly reported, and information on TDA treatment by ZVI was not available based on literature searches conducted for the CMS. Research studies have shown that nitrobenzene and hexachlorobenzene degradation was achieved by ZVI (Mantha etal, 2002, Yang Mu, et al, 2003; and Lu et al, 2004). Aniline was reported as a by-product of the nitrobenzene degradation.

The effectiveness and the application rate of ZVI for treatment of the groundwater constituents to acceptable levels needs to be determined from bench-scale testing. The limiting design factor is generally the constituent with the lowest degradation rate. In addition, the groundwater hydraulic conditions affect the estimated contaminant residence time in the PRB treatment zone and must be factored into the ZVI design. For the purposes of the CMS, the ZVI quantity for SWMU Group A is based on a typical ZVI application rate for chlorinated VOCs with a concentration range of 10-100 ppm. The estimated ZVI application used for the CMS is 40 pounds Fe (0) per square foot of wall.

Potential lateral flow of perched water at SWMU Group A, under current conditions, would be from the interval between the local surface drainage (approx. elev. 625 ft-msl) and the estimated elevation of the perched water (approx. 635 ft.-msl). For the CMS, the PRB technology consists of a series of treatment walls on the south, west and east sides of SWMU Group A to form a continuous wall between SWMU Group A and any surface water drainage areas. The depth of the wall will vary, depending on the surface topography. In general, the PRB will be 20 feet deep or less.

The PRB installation method as proposed in the CMS is conventional trench excavation. Other emplacement methods have been used, depending on site conditions, and include injection, deep soil mixing, bioslurry walls and continuous trenching. The PRB wall would consist of a mixture of ZVI and sand in a trench to approx. elevation 620 ft.-msl around the SWMU GROUP A west, south and east sides, approximately 1600 LF. The estimated ZVI (Fe (0)) quantity for groundwater treatment is 480 tons. The estimated sand quantity is 2000 tons.

The evaluation of Permeable Reactive Barriers is described in the following sections.

6.2.5.2 LONG-TERM EFFECTIVENESS (LIMITED – 0)

- Would protect the surface water from the potential for perched water to migrate horizontally but would not affect perched water which migrates downward.
- ZVI degradation of non-VOC organics present in SWMU Group A perched water have not been fully demonstrated and the formation of toxic by-products compounds produced by the ZVI reactions with nitro aromatics would need to be ruled out by bench-scale testing.
- The gradual corrosion of the ZVI media has been reported and has been found to form precipitation on the metal surface. This causes a reduction in ZVI permeability and reactivity. In some cases this corrosion has not affected the organic degradation rates.

6.2.5.3 REDUCTION OF TOXICITY, MOBILITY OR VOLUME (LIMITED – 0)

- Questionable on reducing mass loading and mobility of contaminants to surface waters and the alluvial aquifer based on the absence of any evidence of treatability for the site SVOCs, especially the nitroaromatic compounds.
- Would treat only the horizontal flow of perched water while most of perched water flow is downward.
- Will not directly reduce or eliminate the toxicity or mass of COIs presently in place.

6.2.5.4 SHORT-TERM EFFECTIVENESS (MODERATE – 1)

- Questions on the effectiveness of treatability of site COIs and the percentage of perched water that would see the PRB.
- Potential for substantial health and safety issues for remedial workers because of excavation and onsite placement of contaminated materials.

6.2.5.5 IMPLEMENTABILITY (DIFFICULT - 0)

- Concerns based on the presence of unstable fill materials, mainly the Ash Lagoon. Construction of the PRB trench may require temporary excavation bracing, especially in unstable fill areas. Trench construction methods will need to be employed, such as bioslurry, which would support the excavation and not require worker access to the trench. Excavation spoils are assumed to be disposable within the SWMU Group A area.
- Potential underground piping and utilities

6.2.5.6 COSTS (MODERATE -1)

The engineering cost estimate summary for the Corrective Action technology is presented **Table 6.2-5**.

<u>CAPITAL</u>

Direct and indirect capital costs have been estimated for the implementation of this remedial technology. Additionally, groundwater monitoring will be a required component of this technology and existing or new monitoring wells will be required to provide for long-term monitoring of SWMU Group A. Major cost components for this technology include:

- Construction management (@ 8% capital costs),
- PRB trench construction, 1600 LF at an average depth of 15 feet, with 6 in HDPE pipe and aggregate backfill. The estimated ZVI (Fe (0)) quantity for groundwater treatment is 480 tons. The estimated sand quantity is 2000 tons.
- Monitoring wells (4) in the Perched groundwater zone around SWMU Group A.

<u>OPERATION AND MAINTENANCE</u>

Long-term O&M costs assuming thirty (30) years of O&M have also been estimated for the implementation of this remedial technology. Annual and periodic costs include:

- Performance monitoring (VOCs, SVOCs and indicator parameters) for 5 years,
- Annual monitoring (VOCs, SVOCs, metals) for 30 years,
- Annual data evaluation and reporting,
- Most PRBs are designed to operate for 20-plus years with safety factors for media corrosion. Operating data beyond a 20 year period has not yet been

available. For purposes of the CMS, maintenance of the PRB is assumed to be negligible for the O&M period.

6.2.5.7 COMMUNITY ACCEPTANCE (HIGH -2)

- No problems or concerns anticipated from the community.

6.2.5.8 STATE ACCEPTANCE (MODERATE -1)

- PRB walls is an acceptable technology and would address established CAOs
- Would expect some concerns with the uncertainty in the effectiveness as well as the potential to create additional COIs

6.2.5.9 SWMU GROUP A PERMEABLE REACTIVE BARRIER (ZVI) – EVALUATION SUMMARY

A SWMU Group A PRB was evaluated for the seven criteria and were scored based on the evaluation. The evaluation results are summarized below:

Long-term Effectiveness	Reduction of Toxicity, Mobility and Volume	Short-term Effectiveness	Implementability	Costs	Community Acceptance	State Acceptance	Overall Numerical Ranking	Selected for SWMU or SWMU Group
Limited 0	Limited 0	Moderate 1	Difficult 0	Moderate 1	High 2	Moderate 1	**5**	**No**

6.2.6 BIOLOGICAL BARRIERS

6.2.6.1 DESCRIPTION

The biobarrier system evaluated for SWMU Group A perched water involves an enhanced biological barrier wall (vertical) configuration across the flow direction of the perched water. Anaerobic supplements would be supplied to the barrier media by direct injection or pumping into a piping system installed in the trench. Contaminated perched water would be treated by microorganisms established within and around the barrier and the water would discharge from the wall under "natural" flow conditions. The operating barrier should be hydraulically passive, and not restrict the existing groundwater flow regime or cause mounding or redirection of the perched water flow.

Biobarrier involves the use of indigenous microorganisms to biodegrade the organic constituents in the subsurface, both in groundwater and the unsaturated zone. The typical system uses injected gases (air) with other supplements and nutrients to increase biological activity. These systems generally operate aerobically. However, other supplements, such as methanol, molasses, sodium lactate, methane and hydrogen gas and other electron donor materials have been injected to enhance anaerobic activity.

Biotechnology has been shown to be effective in treating petroleum hydrocarbons, VOCs and some of the other organics present in SWMU Group A perched water. Chlorinated VOCs and aromatics (benzene) biodegradation has been well established in the literature (USEPA Technology Innovation Office, August, 1998; USEPA NRMRL). Generally, chlorinated VOCs are reduced anaerobically. Aerobic degradation of most chlorinated VOCs is generally much less effective. Case studies of nitroaromatic biodegradation are less commonly reported, and information on TDA treatment was not available based on literature searches conducted for the CMS. Specific cases for biosparging of nitroaromatics and TDA were not found in the literature search, although as indicated for Insitu Biotreatment of Site SWMUs in the Main Plant Area, (ISB Section 6.3.5), nitroaromatics have been found to be successfully treated by anaerobic degradation.

Other barrier applications, such as the "funnel and gate", and sparge wells, have not been evaluated at this time. The "funnel and gate" application, where the biobarrier wall is installed in combination with a containment barrier (sheet pile or slurry wall) to hydraulically direct flow to the permeable wall "gate" is not considered applicable for SWMU Group A since a continuous low permeability layer (aquitard) is not present in the SWMU Group A area. The funnel and gate wall is likely to alter the groundwater hydraulic regime and cause an increase in the water table elevation in the SWMU Group A area. The absence of the aquitard limits the vertical containment ability of the system and may result in an increased vertical migration of groundwater.

Biosparge wells are also not considered applicable at SWMU Group A since the site subsurface conditions are very heterogeneous and stratification of soils/waste is expected. In these conditions, biosupplement transfer from the injection wells could migrate laterally, and would be highly variably distributed.

The biobarrier would consist of a porous fill, such as sand, placed in a continuous trench across the path of the contaminant plume. Other potential media may also be applicable, including organic media (HUMASORB-CS, etc). The most cost-effective barrier media, the biosupplement and nutrient requirements and the site-specific barrier design, will require bench-scale testing with actual perched water from the site. Hydrogen and methane gases would not be used at the site because of their explosion potential. It is anticipated that a hydrogen donor supplement would be injected into the trench to ensure sufficient supplement dispersion throughout the barrier.

The effectiveness of a biobarrier for treatment of the perched water constituents would also be determined from bench-scale testing. The limiting design factor is generally the constituent with the lowest degradation rate and the required residence time within the treatment zone, which is primarily the biobarrier wall. The groundwater hydraulic conditions affect the estimated contaminant residence time and must be factored into the design.

Potential lateral flow of perched water at SWMU Group A, under current conditions, would be from the interval between the local surface drainage (approx. elev. 625 ft-msl) and the estimated elevation of the perched water (approx. 635 ft.-msl). For the CMS, the biobarrier technology consists of a series of treatment walls on the south, west and east sides of SWMU Group A that would form a continuous wall between SWMU Group A and any surface water drainage areas. The depth of the wall will vary, depending on the surface topography. In general, the bio wall would be 20 feet deep, or less.

The biobarrier installation method as proposed in the CMS is conventional trench excavation. Trench excavation is considered a reasonable approach for the installation, especially where the ground surface is relatively flat and open, and the perimeter area of SWMU Group A is not expected to have contaminated materials present in the subsurface.

General design parameters for the SWMU Group A biobarrier wall are as follows:

- Trench excavation to approx. elevation 620 ft-msl around the SWMU Group A west, south and east sides, approximately 1600 LF. The trench will contain sand with perforated pipe and well points. The estimated sand quantity is 2000 tons.
- Biosupplements for enhancement of anaerobic degradation would be identified after bench scale treatability testing. A liquid feed system and trench piping is included with this technology.

The evaluation of the SWMU Group A biobarrier is described in the following sections.

6.2.6.2 LONG-TERM EFFECTIVENESS (N/A)

A shallow biobarrier in SWMU Group A would be intended treat potential lateral flow of perched water from SWMU Group A to protect surface water receptors. An anaerobic biobarrier is considered an "emerging technology" by USEPA and it has not been thoroughly demonstrated to be effective. (USEPA, NRMRL). Anaerobic degradation of the perched water constituents has been reported, but the treatment application was by insitu injection, not by a passive biowall mode. In addition, hydraulic residence times in the barrier trench are expected to be too short to allow sufficient biodegradation, even if constituent treatability can be demonstrated in a bench-scale test. Under passive conditions, a sand barrier (permeability, k ~1 ft/day) at a hydraulic gradient of 0.1 would have a seepage velocity of 0.03 ft/day. The hydraulic residence time for a 3 foot wide trench would be approximately 60 days. This time period is expected to be considerably less than necessary for complete anaerobic degradation of SWMU Group A groundwater constituents. This hydraulic limitation would result in the incomplete treatment of any contaminated perched water that may flow laterally to surface waters. Increasing the trench width a sufficient amount to provide adequate residence time is no practical for SWMU Group A.

Since biobarrier technology has very limited demonstration in similar applications and the trench application at SWMU Group A has hydraulic limitations, the biobarrier is not applicable for perched water treatment at SWMU Group A.

Long-term Effectiveness	Reduction of Toxicity, Mobility and Volume	Short-term Effectiveness	Implementability	Costs	Community Acceptance	State Acceptance	Overall Numerical Ranking	Selected for SWMU or SWMU Group
N/A	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**	**No**

6.2.7 INSITU CHEMICAL OXIDATION (ISCO)

6.2.7.1 DESCRIPTION

In-situ chemical oxidation (ISCO) has been identified as a potential Corrective Action technology for SWMU Group A. Oxidants such as sodium persulfate, iron-catalyzed hydrogen peroxide (Fenton's Reagent), and persulfate (hydroxide-catalyzed) can provide significant reductions in soil and groundwater VOC and SVOC constituents, and in some cases destruction of non-aqueous phase liquids (NAPLs). Bench-scale testing is necessary to determine the treatability of waste constituents, including soils mixed with TDI residue material.

"The two most critical success factors in all ISCO projects are the effective distribution of reagents in the treatment zone and the reactivity of a particular oxidant with the contamination present This combination requires careful site characterizations, screening and feasibility testing. Failure to account for subsurface heterogeneities or preferential flow paths can cause an uneven distribution of the oxidant, resulting in pockets of untreated contaminants … Low-permeable soils and subsurface heterogeneity offer a challenge for the distribution of injected fluids": "Technical and Regulatory Guidance for In Situ Chemical Oxidation of Contaminated Soil and Groundwater", Second Edition, January 2005, prepared by the Interstate Technology Regulatory Council (ITRC)[3] , In Situ Chemical Oxidation Team.

SWMU Group A is a mixed waste area containing construction debris, process residues, polyurethane strands and chunks, solids shipping crates, packing materials, refractory materials, asbestos insulation, polyol and polyether type material, scrap metal, miscellaneous 55-gallon drums, clarifier sludge, process related residues, iron oxide residue and ash slurry from the incineration of clarifier sludge. Since SWMU Group A does not have the characteristics to qualify as a high probability-of-success candidate for ISCO, ISCO is not considered applicable for SWMU Group A and no further evaluation of the technology will be made.

6.2.8 STABILIZATION/SOLIDIFICATION

6.2.8.1 DESCRIPTION

Stabilization/solidification (S/S) as proposed for SWMU Group A involves the insitu introduction of chemical reagents into the waste area to solidify the waste, soils and liquids and immobilize the chemical constituents. Possible S/S reagents include inorganic materials: lime, cements, kiln dusts, silicates and clays as well as pozzolans such as flyash-based; and organics such as

[3] "Established in 1995, the ITRC is a state-led, national coalition of personnel from the environmental regulatory agencies of some 40 states and the District of Columbia; three Federal agencies; tribes; and public and industry stakeholders. The organization is devoted to reducing barriers to, and speeding interstate deployment of better, more cost-effective, innovative environmental techniques. ITRC operates as a committee of Environmental Research Institute of the States (ERIS), a Section 501©(30 public charity that supports the Environmental Council of the

thermoplastic and thermosetting products. Introduction methods include injection, auger/caisson mixing and shallow excavator mixing.

In general, S/S has been used mainly for inorganic waste treatment but organic waste types have been treated as well. Typically, the organic reagents have been used for treatment of organic wastes and inorganic reagents have been used to immobilize mixed waste constituents by macro encapsulation. This process involves mixing of the waste materials with cements or other inorganic materials to solidify the waste mass. This process results in a reduction in waste moisture, permeability and leaching potential.

The COIs At SWMU Group A are: 2,4-toluenediamine (TDA), benzene, dichlorobenzenes, nitrobenzene, 2,4- dinitrotoluene, 2,6- dinitrotoluene, phenol, p-chloroaniline, cadmium and nickel. Applications of S/S for mixed waste with chemical constituents specific to SWMU Group A have not been found in the literature. Generally, because of the numerous options for S/S reagents mixes and the complexity of waste materials, bench-scale testing is necessary to determine viable, optimum treatment mixes. A portion of SWMU Group A may be more effectively treated with a different S/S reagent mix than others.

For purposes of the CMS, a macro encapsulation stabilization technique is proposed to immobilize SWMU Group A waste materials. The approach is based on insitu shallow and deep soil mixing and injection of cement/bentonite reagents using auger-type heavy equipment. Exsitu mixing is considered cost-prohibitive since the entire SWMU Group A would need to be excavated and processed through an onsite mixing operation. General design parameters for S/S of SWMU Group A are as follows:

- Treatment zone is 5-40 ft-bgs over an area of approximately 7 acres. Average waste material thickness is 25 feet. See **Figure 3-1**;
- Reagent application at 20% Portland cement with 2% sodium bentonite admix. Total cement and bentonite proposed are approximately 80,000 and 8,000 tons (dry weight), respectively;
- Pilot-scale field tests over a sub area of SWMU Group A (minimum 2000 sf) to assess reagent delivery methods, dosage and treatability.

The evaluation of S/S is described in the following sections.

6.2.8.2 LONG-TERM EFFECTIVENESS (Limited – 0)

SWMU Group A presents a number of characteristics that limit and may preclude the effectiveness of S/S. These include:

States (ECOS) through its educational and research activities aimed at improving the environment in the United States and providing a forum for state environmental policy makers" (www.itrcweb.org)

- Heterogeneous waste physical characteristics, including debris in the landfill area, which will prevent thorough reagent distribution and mixing,
- Mixed waste organic constituents may interfere with S/S reagent cement reactions,
- Mixed wastes, especially the organic fraction, would not be expected to be completely immobilized by S/S, especially over the long term. Contaminant leaching would be reduced from the current conditions, however, some leaching would be expected over the long term since the treated waste mass would not be impermeable, and the waste constituents, especially the organics, would not be destroyed in the treatment process.

6.2.8.3 REDUCTION OF TOXICITY, MOBILITY OR VOLUME (Moderate - 1)

- The implementation of S/S for SWMU Group A would likely reduce, but not eliminate, the potential for leaching of COIs to groundwater (i.e. mobility).
- The treatability of the waste fill constituents and the TDI residues will need to be evaluated by bench-scale testing. Quantification of leaching reductions and groundwater quality improvements cannot be reasonably estimated at this time.
- The toxicity and volume of the COIs wastes would not effectively change since the treatment would not significantly alter or destroy the chemical constituents..
- Metals immobilization would be significant since reactions with the metals will result in the formation of less soluble metal hydroxide, carbonate and silicate compounds.

6.2.8.4 SHORT-TERM EFFECTIVENESS (Limited – 0)

S/S waste encapsulation occurs in relatively short time periods after mixing. Concerns include:

- Potential exposure of site workers to the chemical reagents as well as to heat and off-gas generation.
- Potential for reaction-induced effects such as the generation of excessive heat and VOC off-gases.

6.2.8.5 IMPLEMENTABILITY (Difficult – 0)

- The primary concern is the presence of <u>large and bulky debris</u>. S/S reagent placement can be performed with specialized shallow and deep soil mixing equipment, however, bulky materials will prevent the operation of mixing equipment and the distribution of reagents would be limited in those areas.
- <u>Free liquids</u> within the waste fill may contain significant levels of contaminants, including NAPLs which would be displaced during reagent mixing and injections.

Containment systems, such as a continuous perimeter drain, would be required to prevent seepage and potential offsite migration of contaminants.

- At a typical soil mixing treatment rate of 500-1000 cy per day, the time to perform the treatment of SWMU Group A would be 1-2 years with a single mixing auger unit.

6.2.8.6 COSTS (HIGH – 0)

The engineering cost estimate summary for the S/S Corrective Action technology is presented in **Table 6.2-6**.

Direct and indirect capital costs have been estimated for the implementation of this Corrective Action technology. Major cost components for this technology include:

- Construction management (@ 8% capital costs),
- Reagent application at 20% Portland cement with 2% sodium bentonite admix. Total cement and bentonite proposed are approximately 80,000 and 8,000 tons (dry weight), respectively;
- A 2000 ton/day pug mill operation will be used to blend the cement/bentonite mixture,
- A 2000 ton/day batch concrete plant will be used to make the S/S slurry for injection,
- Shallow and deep soil mixing augers will be used to inject and blend the S/S reagents,
- And four (4) new monitoring wells in the alluvial aquifer at the POC.

Long-term O&M costs assuming thirty (30) years of O&M have also been estimated using the following assumptions:

- Annual groundwater performance monitoring, data evaluation and reporting for 5-years (VOCs, SVOCs, metals)
- Monitoring well replacement (20%/5 years),
- Recovery well operation and perched water collection for 5 years (@5% capital costs/year) are required. Costs are addressed in Sections 6.8 and 6.9,
- Groundwater treatment for 5 years (@ $1.00/1000 gallons) are required. Costs are addressed in Sections 6.8 and 6.9.

6.2.8.7 COMMUNITY ACCEPTANCE (High – 2)

- No problems or concerns expected.

6.2.8.8 STATE ACCEPTANCE (Low – 0)

- Concerns are anticipated based on the uncertainties of the effectiveness of the technology and the potential for formation of new COIs with introduction of S/S reagents into the subsurface.

6.2.8.9 SWMU GROUP A- SOLIDIFICATION/STABILIZATION EVALUATION SUMMARY

Solidification/Stabilization of SWMU Group A was evaluated for the seven criteria and was scored based on the evaluation. The evaluation results are summarized below:

Long-term Effectiveness	Reduction of Toxicity, Mobility or Volume	Short-term Effectiveness	Implementability	Costs	Community Acceptance	State Acceptance	Overall Numerical Ranking	Selected for SWMU or SWMU Group
Limited 0	Moderate 1	Limited 0	Difficult 0	High 0	Moderate 2	Low 0	**3**	**No**

6.2.9 ON-SITE INCINERATION (BAYER FACILITY)

6.2.9.1 DESCRIPTION

On-site incineration utilizing existing facilities at the Bayer New Martinsville Plant has been identified as a potential Corrective Action technology for SWMU Group A. Bayer currently operates a RCRA-permitted incinerator in Block 21 that is used primarily for burning TDI residues. The system permit allows for 8500 lb/hr of waste with a BTU value of >4000 BTU/lb. Soil treatment is allowed in the permit However, Bayer has not treated soils to-date and no facilities currently exist for handling large volumes of soils/debris. These facility upgrade costs are included in the cost estimate as direct capital costs. Ash from the incinerator is considered hazardous waste and is sent offsite for landfill disposal.

Any ex-situ treatment technology such as on-site incineration / disposal requires excavation and removal of SWMU Group A and raises the following concerns for remedial operations within operating facilities:

- Protection of construction and Bayer operating personnel from physical injury or exposure to releases.
- Protection of adjacent, subsurface and overhead process piping and utility systems and the functionality of sensitive electronic process communications, instrumentation and operational controls.
- Physical access limitations
- Protection of the structural and functional aspects of the physical plant

The excavation zone is 0-45 ft-bgs over an area of approximately 7 acres. Average depth of excavation is 25 feet. Excavations will include zones beneath the water table and will require dewatering. Total waste material volume is estimated at 325,000 tons. See **Figure 3-1.** For SWMU Group A, the waste types are known to be mixed waste materials, including soils, debris, ash, sludges, and TDI residues. The SWMU Group A waste soils and interspersed TDI residues are all assumed to be RCRA wastes.

Capacity of Bayer's incinerator and its lack of a mechanism to feed solids or proven operability are principle concerns. The available capacity of the Bayer incinerator is approximately 0.25 tons/hr, or 6 tons/day. The large volume of waste or even a small fraction of the approximately 325,000 tons of waste would overwhelm the current available capacity of the onsite incinerator. This equates to a waste processing time of 148 years at 100% operations. Therefore, on-site incineration would involve building and permitting an on-site hazardous waste incinerator since the current facility is not a feasible option. Therefore, on-site incineration has been eliminated from further consideration**.** Cost estimates have not been prepared at this time.

6.2.10 INCINERATION (OFF-SITE)

6.2.10.1 DESCRIPTION

Incineration utilizing commercial facilities is a potential Corrective Action technology for SWMU Group A. As of 2005, there are 12 commercial hazardous waste incineration facilities operating in North America (Ref: EI, 2005). Nine (9) facilities are in the United States. Total 2005 commercial capacity is approximately 500,000 tons per year. It is noted that 85% of the wastes handled by these facilities are aqueous and organic liquids. The remaining 15% are solids and sludges, such as are present in SWMU Group A. If it is assumed that the solids/sludges treatment capacity is 15% of the total, then the total solids/sludges incineration capacity is approximately 75,000 tons/year. Most of the facilities are reported to be operating at full capacity.

Total waste material volume in SWMU Group A is estimated at 325,000 tons. If full capacity (100%) of all of the North American commercial facilities was available, processing of the SWMU Group A waste volume would take 5 years. Assuming 20% of the North American incineration capacity is available, processing of the SWMU Group A waste volume would take 22 years. The commercial incineration capacity is, however, assumed to be inadequate for handling the estimated waste quantity at SWMU GROUP A within a reasonable time frame (< 5 years).

Based on a typical RCRA incineration cost of $300/ton, incineration alone would cost an estimated $97,500,000 for the 325,000 tons of material in SWMU Group A. Significant additional costs would be realized for excavation, waste preparation, transportation and site restoration.

Therefore, based on capacity and cost considerations, off-site incineration has been eliminated from further consideration.

6.2.11 Off-site Landfilling

6.2.11.1 Description

Off-site landfilling is a potentially applicable ex-situ Corrective Action technology for SWMU Group A. Both RCRA TSD and non-hazardous commercial waste disposal facilities are anticipated for disposal. The portion of the waste materials that will be disposed of by either means will depend on waste classifications, onsite waste segregation, and onsite waste treatment performance.

For purposes of the CMS, it is assumed that 50% of the SWMU Group A waste volume, or 162,500 tons, are listed hazardous wastes. These wastes would require disposal at a RCRA landfill facility. This listed waste quantity was based on the estimated volume of the ash lagoon and the original South Landfill waste fill that is currently below grade. The lagoon is expected to contain mainly ash "derived from" the burning of wastewater sludge, which contained several now-listed "K" wastes. The South Landfill deep (below-grade) waste deposits are expected to contain the bulk of the sludges and chemicals that were landfilled prior to the onset of RCRA regulations. The remaining waste volume, 162,500 tons, is assumed to be RCRA-characteristic wastes.

Under the USEPA 40 CFR 268 Hazardous Waste Regulations, Land Disposal Restrictions (LDRs), waste treatment standards have been established for land disposal of certain hazardous wastes. If the wastes do not meet these standards, they may require treatment prior to disposal. In addition, characteristic wastes would need to be treated to remove their RCRA characteristics prior to offsite disposal. These wastes would likely be able to be disposed of at a non-hazardous waste disposal landfill. Specific constituents found consistently at SWMU Group A and their RCRA LDR treatment standards under 40 CFR 268.40 are as follows:

Waste Constituent (40 CFR 268.40)	***Treatment Standard, mg/kg***	***Maximum SWMU detection (RFI), mg/kg***
Benzene (D018)	10	1220 (SWMU 4)
Chlorobenzene (D021)	6	7520 (SWMU 4)
Dichlorobenzenes (D027 and D028)	6	3480 (SWMU 4)
2,4- Dinitrotoluene (D030)	140	Data incomplete
Nitrobenzene (D036)	14	Data incomplete
Cadmium	0.11 mg/l TCLP	618 (total), (SWMU 2)
Chromium	0.60 mg/l TCLP	96,500 (total), (SWMU 2)
F-listed wastes	Varies (specific waste)	NA
K027- Centrifuge and distillation residues from toluene diisocyanate (TDI) production	Combustion – as defined by 268.42	NA
Other listed waste (K, P, U)	Varies (40 CFR 268.40)	NA

These maximum constituent levels indicate that the wastes are likely to exceed LDR standards and require further treatment prior to offsite landfill acceptance per the LDR standards. Regulatory options for treatment of the materials would include:

- Treat constituents to 268.40 standards,
- Obtain a treatability variance under 268.44,
- Use alternative treatment standards in 268.49.

In all cases, the waste materials are expected to require treatment prior to offsite landfilling. Thermal treatment processes are identified for the organic wastes.

Based on a typical RCRA landfill cost of $150/ton, landfilling of hazardous wastes (RCRA-listed) alone would cost an estimated $24,375,000. Non-hazardous waste disposal is estimated to cost $50/ton, or a total of $8,125,000. Total disposal costs alone are $32,500,000. Significant additional costs would be realized for excavation, waste preparation, onsite treatment, transportation and site restoration. These costs are expected to range from $15-25MM. Total costs for implementation of this technology for SWMU Group A are estimated to be from $47.5 to $57.5MM.

Therefore, based on excavation, treatment and cost considerations, off-site landfill has been eliminated from further consideration.

6.2.12 SITE-WIDE GROUNDWATER CONTAINMENT AND TREATMENT

Site-wide Groundwater Containment and Treatment will be evaluated in detail in **Section 6.4 Site-Wide Groundwater.** At this stage of the CMS, Site-wide Groundwater Containment and Treatment will be "retained" for SWMU Group A.

6.2.13 TRENCHES AND/OR RECOVERY WELLS FOR PERCHED WATER

Trenches and / or recovery wells is a potential technology to address contaminated perched water in SWMU Group A. Perched water is defined as discontinuous saturated zones with water elevations above the larger Site water table (alluvial aquifer). Detailed descriptions of Site groundwater conditions are contained in the RFI, Section 7.0 (IT, 2001) and in other historic site reports, most notably the Description of Current Conditions (ICF, 1995), the Procedures and Results of Investigation Required under USEPA Consent Order (Geraghty and Miller, Inc, 1988) and the Final Report Hydrogeologic Conditions at the Mobay Chemical Corporation Plant Site (Geraghty and Miller, Inc, 1985). Chemical analyses for perched water areas are contained in the Geraghty and Miller, Inc, 1985 report. The findings of these investigation reports provide the basis for the evaluation of technologies to address perched water.

Perched water can flow both horizontally (laterally) and vertically. In the South Landfill area of SWMU Group A, perched water conditions are very complex because of the heterogeneous deposits of waste materials and cover soils. The perched flow in this area has been determined to be mainly downward, recharging the alluvial aquifer. However, wet-weather seeps have been reported along certain portions of the landfill perimeter, particularly the south and east ends. These seeps have been observed to flow in direct response to precipitation/infiltration.

Perched water levels are generally between elevations 625-630 ft-msl in the South Landfill area. The base of the landfill is at approximate elevation 611 to 615 feet. The original natural ground surface in the area (El 630-635) was excavated in the early 1970's to remove up to 20 feet of soils. In addition, the ash lagoon area was used as a borrow area, and the base of this lagoon is estimated to be at or near elevation 615 feet. The alluvial aquifer potentiometric surface elevations (under pumping conditions) generally range from elevations 618-623 ft-msl. The top of the alluvial aquifer varies throughout the plant area, and is generally between elevations 600-620 ft-msl. A fine-grained (clayey-silt) layer (aquitard) separates the perched water from the underlying alluvial aquifer over the main plant area. This aquitard varies in thickness, and is generally thinner where eroded by the former stream that ran through the main plant. In the SWMU Group A area, the aquitard has been completely to partially excavated prior to development of the landfill and ash disposal lagoon. The aquitard appears to be completely absent beneath the sludge lagoon.

Chemical analyses of perched water in SWMU Group A indicates a range of detected volatile and semi-volatile compounds, with highly variable concentrations. The perched water has been sampled from the following points:

- Geraghty and Miller monitoring points from 1987 site investigations: LF-1P, -2P, -5P, -6P and 7P. See **Figures 3-1 and 3-2** for the monitoring point locations.

Perched water chemical analyses are summarized as follows:

Perched water Analyses Summary- 1987 Investigations						
Chemical Compound, ug/l unless otherwise indicated						
Monitoring Point	**Benzene**	**Chlorobenzene**	**Dichlorobenzenes**	**Nitrobenzene**	**Nitrotoluenes**	**Toluenediamine**
South Landfill						
LF-1P	210	6000	260		100	33,700
LF-2P						
LF-5P	170	1190	60	10	30	730
LF-6P		1570	50	70	110	
LF-7P		2100	200			

Note: Blank entry indicates non-detected (ND)

The objective of addressing perched water in the SWMU Group A is to assist in the achievement of the following Site CAOs:

- Provide for the continued control of potential off-site migration of contaminated groundwater to a level that is protective of surface water quality.
- Implement reasonable efforts to eliminate or mitigate further releases of contaminants from Site SWMUs (using the site boundary as the point of compliance).
- Reduction of contaminant levels, as practicable, over time to support reasonably expected use.

TECHNOLOGY DESCRIPTION

Collection involves interception of the perched water from the elevation of the local surface drainage (approx. 625 feet) to the estimated surface elevation of the perched water (approx. 635 feet). To assure complete collection of any laterally migrating waters, the collection system will need to address the perimeter of the SWMU GROUP A where it abuts surface water drainage, i.e., on it's south, west and east sides. The interception of perched water will be by a series of subsurface collection drains. The drains will be placed in segments of 300 feet or less in length, with each section sloped to a collection sump. The depth of the trench and sumps will vary, depending on the surface topography. In general, the trench will be 20 feet deep or less. The collection sumps will be greater depths. Each sump will have a submersible pump that conveys collected liquids to a local lift station from which the waters would be pumped to the plant wastewater treatment system.

For purposes of the CMS evaluation, the collection system design is based on the assumption that 100% of the estimated net infiltration into SWMU Group A Area under uncapped conditions is intercepted. For a vegetated cover condition, the net infiltration is estimated to be 10 inches per year. Over 7 acres, the annual volume would be 70 acre-inches, or approximately 1,900,000 gallons. General design parameters for the SWMU Group A perched water collection drain are as follows:

- Interceptor trench to approx. elevation 620 feet around the SWMU GROUP A west, south and east sides, approximately 1600 LF. The trench will contain a perforated HDPE pipe and be backfilled with coarse aggregate for a minimum 10 feet depth,
- Five collection sumps with submersible pumps that discharge to a central lift station for conveyance to the onsite wastewater treatment system,
- Average flow from the system will be 3.6 gpm,

The evaluation of Perched water Collection at SWMU Group A is described in the following sections.

6.2.13.1 LONG-TERM EFFECTIVENESS (Moderate – 1)

- ➢ Would provide some assistance in meeting the CAO for controlling the potential of off-site migration of contaminated groundwater and reduction of contaminant levels of Site Groundwater.
- ➢ Effective in collecting perched waters that may otherwise migrate laterally from the SWMU Group A area to surface waters. But a perimeter drain would not collect all of the perched water, allowing some to continue to migrate vertically to the alluvial aquifer.

6.2.13.2 REDUCTION OF TOXICITY, MOBILITY OR VOLUME (Moderate – 1)

- ➢ Effective in reducing contaminant mass loading to the alluvial aquifer and minimizing the potential for mass loading to surface waters
- ➢ No effect on the toxicity or mass of COIs presently in place.

6.2.13.3 SHORT-TERM EFFECTIVENESS (Moderate – 1)

- ➢ Reduced potential for contaminant migration to surface waters.
- ➢ Reduced contaminant mass loading to the alluvial aquifer.
- ➢ Short-term increase in the potential for health and safety issues for site and construction workers during implementation of Corrective Action (i.e. from excavation and onsite placement of contaminated materials).

6.2.13.4 IMPLEMENTABILITY (Difficult – 0)

- ➢ Traditional technology but difficult to implement on a large scale within a mixed waste landfill.
- ➢ Main concern: the presence of unstable fill materials, mainly the Ash Lagoon; underground piping and utilities; and handling of contaminated materials.

6.2.13.5 COSTS (Moderate – 1)

The engineering cost estimate summary for the groundwater collection trench technology is presented in **Table 6.2-7**.

CAPITAL

Direct and indirect capital costs have been estimated for the implementation of this Corrective Action technology. Additionally, groundwater monitoring will be a required component of this technology and existing or new monitoring wells will be required to provide for long-term monitoring of SWMU Group A. Major cost components for this technology include:

- Construction management (@ 8% capital costs),
- Trench construction, 1600 LF at an average depth of 15 feet, with 6 in HDPE pipe and aggregate backfill. Excavation spoils disposal is assumed to be onsite within SWMU Group A.
- Sumps (5), consisting of 6 ft diameter HDPE manhole sections, average depth 20 feet,
- Sump pumps (5) and discharge lines (approx 4000 LF 1- in HDPE),
- Local lift station (6 ft diameter HDPE manhole) with pump and discharge line to wastewater treatment system, approx 500 LF,
- Monitoring wells, 2-in, (8) around the collection drain,

OPERATION AND MAINTENANCE

Long-term O&M costs assuming thirty (30) years of O&M have also been estimated for the implementation of this Corrective Action technology. Annual and periodic costs include:

- Maintenance and replacement (@ 3% capital cost/year),
- Wastewater treatment onsite at $1.0/1000 gallon, estimated 1.9MM gal/year,
- Annual monitoring (VOCs, SVOCs, metals),
- Annual data evaluation and reporting,

6.2.13.6 COMMUNITY ACCEPTANCE (High – 2)

- ➢ Community concerns are not expected with this industrial site.

6.2.13.7 STATE ACCEPTANCE (Moderate – 1)

- ➢ Acceptance expected
- ➢ Some concerns with constructability and health and safety issues expected
- ➢ Site CAOs would be positively affected.

6.2.13.8 SWMU Group A Subsurface Collection Drain – Evaluation Summary

A SWMU Group A subsurface collection drain was evaluated for the seven criteria and were scored based on the evaluation. The evaluation results are summarized below:

Long-term Effectiveness	Reduction of Toxicity, Mobility and Volume	Short-term Effectiveness	Implementability	Costs	Community Acceptance	State Acceptance	Overall Numerical Ranking	Selected for SWMU or SWMU Group
Moderate 1	Moderate 1	Moderate 1	Difficult 0	Moderate 1	High 2	Moderate 1	7	Yes

6.2.14 Corrective Action Alternative Ranking Summary - SWMU Group A

As indicated in Section 6.1.8, each of the potential Corrective Action technology alternatives for SWMU Group A was ranked following the completion of the criteria evaluations. **Table 6.2-8** presents a summary of the non-discounted direct/indirect capital costs, O&M (annual) costs, and associated periodic costs for each of the evaluated Corrective Action technologies for comparative purposes. Present value calculations were completed for each of the individual Corrective Action technologies with the key assumption that the given technology was the only remediation required for that SWMU or SWMU Group. **Table 6.2-9** presents a summary of the present value calculations for the evaluated Corrective Action technologies in SWMU Group A.

SWMU Group A technologies carried forward to **Section 7.0** evaluation area as follows:

SWMU Group A Section 6.0 Technology Evaluation	
Technology	***Evaluation Result***
Institutional Controls	**Retained**
Covers/Caps (Soil, pavement and/or synthetic membranes)	**Retained**
Containment Barriers (Sheet piles, slurry walls, synthetic membranes)	**Retained (slurry wall)**
Passive Treatment Walls [Vertical walls constructed by trenching and/or injection.]	
Zero-valent iron (ZVI)	X
Biosparging	X
In-Situ Treatment	
In-situ Chemical Oxidation (ISCO)	X
In-situ Biological (ISB) [Aerobic and/or Anaerobic]	
Chemical Flushing	
Soil Vapor Extraction (SVE)	
Enhanced SVE (In-situ thermal desorption by resistance and/or RF heating)	
Stabilization	X
Ex-Situ Treatment/Disposal [Assumes removal by excavation and/or pumping]	
On-site Incineration (Bayer Facility)	X
Off-site Incineration	X
Thermal Desorption	
Biopiles / Landfarming	
Soil Washing	
Off-site Landfill	X
Groundwater Treatment	
Enhanced Site-wide Groundwater Containment and Treatment	**Retained**
Natural Attenuation	
Trenches and/or recovery wells (perched water)	**Retained**

X – ***Evaluated and eliminated from further consideration***

6.3 MAIN PLANT AREA (MPA) SWMUS

6.3.1 SWMU / SWMU GROUPS DESCRIPTIONS AND RELATED SITE-WIDE CAOS

The Main Plant Area (MPA) contains all of the site SWMUs or SWMU Groups of interest with the exception of SWMU Group A. The SWMU Groups and SWMUs within the MPA have significant similarities, including surface and subsurface conditions and contaminant types that allow potential Corrective Action technologies to be evaluated for the MPA as a whole to facilitate the CMS process. Individual differences in the SWMUs or SWMU Groups significant to a particular Corrective Action technology evaluation, are addressed as appropriate. A brief summary of the individual MPA SWMUs or SWMU Groups is contained in the following sections. See **Figure 3-2** for the MPA location, as well as the locations of MPA SWMUs or SWMU Groups.

The specific issue to be addressed by this CMS with respect to Site Soils is the potential for Site Soils associated with certain Site SWMUs to leach COIs to Site Groundwater in concentrations of potential concerns, based on screening of the Site Soil COI concentrations against the site specific SSLs. Site Soils containing COIs in excess of the SSLs are to be addressed as a potential source for the COIs identified in groundwater. Site-wide CAOs related to MPA SWMUs are bolded in the site-wide CAO list below:

- At all times, prevent unacceptable human exposure (carcinogenic risk > 1 x 10^{-6} and Hazard Index > 1) from affected Site Groundwater and Site Soils

The Site Soil CAOs are as follows:

- Prevent unacceptable industrial worker exposures to shallow (0 to 2 ft-bgs) surficial soil COIs (i.e. detected contaminants),
- Prevent unacceptable construction worker exposures to subsurface (0 to 5 ft-bgs) soil COIs, and
- Prevent unacceptable construction worker exposures to soil COIs (at all depths).

The Site-wide Groundwater CAOs are as follows:

- Prevent unacceptable human exposures to recovered contaminated groundwater,
- Maintain current groundwater recovery well system operation for groundwater collection and plume hydraulic containment within the Site boundary, and
- Provide for the continued control of potential off-site migration of contaminated groundwater to a level that is protective of surface water quality.
- Implement reasonable efforts to eliminate or mitigate further releases of contaminants from SWMUs (using the site boundary as the point of compliance).
- Reduction of contaminant levels, as practicable, over time to support reasonably expected use.

6.3.1.1 SWMU GROUP B

SWMU Group B is a former bulk TDI residue fill area and lies underneath the Bayer Plant wastewater and storm water storage and treatment facilities. The existing facilities have either been constructed on or within fill material consisting of alluvial soils interspersed with TDI residues. The entire SWMU Group B area is within the operating boundaries of the plant, which has controlled access. The area of SWMU Group B is estimated to be approximately 10.5 acres. SWMU 5 currently contains an equalization basin, approximately 2 acres in area, and a rainwater storage basin, approximately 1.2 acres in area. The average depth of the basins is 20 feet. The existing Bayer Plant wastewater treatment facility includes two (2) 125- ft diameter clarifiers, two (2) 100-ft diameter aeration tanks, and other small support buildings. Any intrusive operation and maintenance activities for the area, and for immediately adjoining facilities, will need to be addressed in the institutional controls.

Based on the RFI exposure risk assessment, no further action is warranted in SWMU Group B based on the calculated risks for industrial and construction worker scenarios. The comparison of soil concentrations to SSLs indicate a potential for COIs to leach to groundwater at potentially unacceptable concentrations.

6.3.1.2 SWMU GROUP C

SWMU Group C contains three relatively small areas (SWMUs 8, 9 and 11), and one large general residue fill area (SWMU 7). SWMUs 8 and 11 were former waste treatment pits, from 200-400 sf in area, ranging from 7-10 feet deep. SWMU 9 was a temporary residue storage pile area, approximately 100 by 140 feet. SWMUs 8, 9 and 11 are in open, non-operations areas. SWMU 7 encompasses an approximately 4 acre area in Block 21 that includes the incinerator facilities, the fuel oil storage tank area and the other SWMUs within the group. The entire SWMU Group C area is within the operating boundaries of the plant, which has controlled access.

The SWMU Group C Area has either been constructed on or within fill material consisting of alluvial soils interspersed with miscellaneous solid waste debris and TDI residues. Any intrusive operation and maintenance activities for the area, and for immediately adjoining facilities, will need to be addressed in the institutional controls.

Based on the RFI exposure risk assessment, no further action is warranted in SWMU Group C based on the calculated risks for industrial and construction worker scenarios. The comparison of soil concentrations to SSLs indicate a potential for COIs to leach to groundwater at potentially unacceptable concentrations.

6.3.1.3 SWMU GROUP D

SWMU Group D encompasses the former wastewater trench (SWMU 10) and acid neutralization basin system. The trench was located in a former stream channel that ran through the plant and was connected to the neutralization basins (SWMUs 12, 15 and 16). The trench segment identified as SWMU 10 contains a main branch approximately 1850 feet long, and a lateral section approximately 400 feet in length. SWMU 12 was reported to be 30 ft by 100 ft by 17 ft deep. SWMUs 15 and 16 are smaller, with dimensions of 10 ft by 30 ft and 12 ft by 12 ft by 15 ft, respectively. The depth of SWMU 15 is not known. Each of the basins were unlined pits used for acid wastewater neutralization. The trench and basins have all been backfilled.

The entire SWMU Group D area is within the operating boundaries of the plant, which has controlled access. Any intrusive operation and maintenance activities for the area, and for immediately adjoining facilities, will need to be addressed in the institutional controls.

Based on the RFI exposure risk assessment, no further action is warranted in SWMU Group D based on the calculated risks for industrial and construction worker scenarios. The RFI concluded that Group D should be evaluated in the CMS as a potential source area for COIs in groundwater.

6.3.1.4 SWMU 21

SWMU 21 is the former Nitrations Neutralization Basin 5Fc. This unit was used to treat wastewater from the Nitrations Process Area with limestone. The unit was an unlined earthen basin 30 ft by 30 ft in area. Depth is not known. Effluent was discharged to the main process trench.

Based on the RFI exposure risk assessment, no further action is warranted at SWMU 21 based on the calculated risks for industrial and construction worker scenarios. The comparison of soil concentrations to SSLs indicate a potential for COIs to leach to groundwater at potentially unacceptable concentrations.

6.3.1.5 SWMU 27

SWMU 27 consists of two small areas, one located on the southeastern side of Block 27 and the other on the western side of Block 17. Two releases have been recorded in Blocks 17 and 27 from product pipelines. One release occurred on January 16, 1994 and consisted of approximately 400 pounds of benzene. The second release occurred on January 17, 1994 and consisted of approximately 150 pounds of benzene. The spilled material was collected and contaminated soils were containerized and shipped offsite for proper disposal.

Based on the RFI exposure risk assessment, no further action is warranted at SWMU 27 based on the calculated risks for industrial and construction worker scenarios. The comparison of soil concentrations to SSLs indicate a potential for COIs to leach to groundwater at potentially unacceptable concentrations.

6.3.1.6 MPA SWMUS / SWMU GROUPS TECHNOLOGIES FOR EVALUATION

The technologies identified for MPA SWMUs that remained after the screening step are summarized in **Table 5-23** and include the following:

MPA SWMU Technology Screening Summary	
Technology	***Screening Result***
Institutional Controls	**Retained**
Covers/Caps (Soil, pavement and/or synthetic membranes)	**Retained**
Containment Barriers (Sheet piles, slurry walls, synthetic membranes)	**Retained**
Passive Treatment Walls [Vertical walls constructed by trenching and/or injection.]	
Zero-valent iron (ZVI)	X
Biosparging	X
In-Situ Treatment	
In-situ Chemical Oxidation (ISCO)	**Retained**
In-situ Biological (ISB) [Aerobic and/or Anaerobic]	**Retained**
Chemical Flushing	X
Soil Vapor Extraction (SVE)	X
Enhanced SVE (In-situ thermal desorption by resistance and/or RF heating)	X
Stabilization	X
Ex Situ Treatment/Disposal [Assumes removal by excavation and/or pumping]	
On-site Incineration (Bayer Facility)	**Retained**
Off-site Incineration	**Retained**
Thermal Desorption	X
Biopiles / Landfarming	X
Soil Washing	X
Off-site Landfill	**Retained**
Groundwater Treatment	
Enhanced Site-wide Groundwater Containment and Treatment	**Retained**
Natural Attenuation	X
Trenches and/or Recovery Wells (Perched water collection)	X

X – *Evaluated and eliminated from further consideration*

Some of the retained technologies were judged to be not applicable to SWMU 27 because of its relatively small size (<300 sf) and complete evaluations were not performed. These technologies are noted as such in the text.

6.3.2 INSTITUTIONAL CONTROLS

The evaluation of Institutional Controls for ICs for MPA SWMUs is analogous to the evaluation of ICs for SWMU Group A described in **Section 6.2.1 Institutional Controls**. ICs are currently in place for MPA SWMUs and will be formalized. This technology will be carried forward to Section 7.0 for incorporation in site-wide alternatives. The engineering cost estimate summary for the ICs are presented in **Table 6.3-1**.

6.3.3 CAPS/COVERS

Cap/cover technology is very difficult to implement on most of the MPA SWMUs because of on-going operations, operating facilities and structures, underground and overhead piping and communications links. Summarizing MPA SWMUs relative to the potential for Caps/Covers:

- o SWMU Group B (5 & 6): SWMU 5 (~10.5 acres) contains an equalization basin (~2 acres) and a rainwater storage basin (~ 2 acres). SWMU 6 contains large tanks (waste water treatment plant clarifiers and bio-oxidation tanks).
- o SWMU Group C (7, 8, 9 & 11): SWMUs 8, 9 and 11 are in open areas but are relatively small (100 – 400sf each), separate areas. SWMU 7 is an approximately 4-acre area that includes the incinerator facilities and the fuel oil storage tank area.
- o SWMU Group D (10, 12, 15 & 16): SWMU 10 is a long relatively narrow strip of land (2250 ft. by 30ft) that is an in-filled former wastewater trench running through a major portion of the operating facility. In some areas the beneath plant facilities and structures. SWMU 12 is the former neutralization spill basin located within SWMU 10 and measures approximately 30 ft by 100 ft. SWMU 15 consists of two small former basins (Neutralization and Settling Basins 5Fa) that have been backfilled. SWMU 16 is the former Neutralization Basin (5Fe) that has been backfilled and measures 12 ft by 12 ft.
- o SWMU 21 is a former 30 ft. by 30 ft. unlined earthen basin that was backfilled in 1971. It is located in the northern section of Block 16. The presence of above-ground piping, underground piping & utilities and two structures with process piping and utilities over SWMU 21 makes capping impractical.
- o SWMU 27 consists of two benzene spill areas and is located on the western side of Block 17 in an accessible area of the Site.

SWMU 27 is the only MPA SWMU where a cap/cover is feasible. The following evaluation is for SWMUs 21 and 27 only.

6.3.3.1 DESCRIPTION

The cap/cover Corrective Action technology for the MPA SWMU 27 has been assumed to consist of the following for cost estimating purposes:

- Sub-base soil to achieve minimum 2% grade (avg. 1 ft thick),

- Engineered soil or synthetic cap / cover. Assumptions for cost estimating purposes include: Geotextile base (non-woven), HDPE membrane (80-mil), geosynthetic drainage net, final cover soil (2 ft thick) and vegetation;
- Groundwater monitoring at the POC is assumed for cost estimating purposes.

See **Figure 3-2** for the SWMU / SWMU Group locations.

The evaluation of Caps/Covers is described in the following sections.

6.3.3.2 LONG-TERM EFFECTIVENESS (Moderate - 2)

- ➢ Moderate improvement in meeting CAOs for Site Groundwater vs. current operation of pump and treatment and containment of Site Groundwater.
- ➢ Would assist in further limiting worker exposure potential to subsurface contaminants.
- ➢ Effectiveness will be difficult to measure due to the historic co-mingling of plumes from other Site SWMUs.

6.3.3.3 REDUCTION OF TOXICITY, MOBILITY OR VOLUME (Limited-0)

- ➢ No reduction in toxicity or volume of waste (& COIs)
- ➢ Mobility of the COIs minimized through reduced leaching.

6.3.3.4 SHORT-TERM EFFECTIVENESS (Limited – 0)

- ➢ Increased potential for construction worker exposure during installation.

6.3.3.5 IMPLEMENTABILITY (MODERATE - 1)

- ➢ Conventional technology.
- ➢ Some above ground structures.
- ➢ Underground piping and utilities that would be covered by the cap would need to be relocated for future access.

6.3.3.6 COSTS (LOW – 1)

The engineering cost estimate summary for the cap/cover Corrective Action technology is presented in **Table 6.3-2**. Cost component assumptions for this technology include:

- Construction management (@ 8% capital costs),
- Site grading to achieve min. 2% grade
- Engineered cap / cover consisting of: Geotextile base (non-woven), HDPE membrane (80-mil), geosynthetic drainage net, final cover soil (2 ft thick) and vegetation,
    - o Long-term O&M costs assuming thirty (30) years of O&M have also been estimated for the implementation of this Corrective Action technology.

6.3.3.7 COMMUNITY ACCEPTANCE (HIGH – 2)

- No concerns or objections expected.

6.3.3.8 STATE ACCEPTANCE (HIGH – 2)

- No concerns or objections expected.

6.3.3.9 MAIN PLANT AREA SWMUS - CAPS/COVERS EVALUATION SUMMARY

Caps/covers for MPA SWMU 27 were evaluated for the seven criteria and were scored based on the evaluation. The evaluation results are summarized below:

SWMU Group/SWMU	Long-term Effectiveness	Reduction of Toxicity, Mobility and Volume	Short-term Effectiveness	Implementability	Costs	Community Acceptance	State Acceptance	Overall Numerical Ranking	Selected for SWMU or SWMU Group
B,C,D, 21	n/a	n/a	n/a	n/a	n/a	n/a	n/a	**n/a**	**No**
27	Moderate 1	Limited 0	Effective 2	Moderate 1	Low 1	High 2	High 2	**9**	**Yes**

6.3.4 CONTAINMENT BARRIERS- SLURRY WALL

6.3.4.1 DESCRIPTION

The purpose of these types of barriers is to contain the contaminant/waste area, reduce lateral hydraulic loading, and/or to reduced/eliminate the lateral migration potential of source materials or dissolved phase constituents into the groundwater.

Currently, contaminated groundwater migration from the MPA is contained by the site recovery well system (Ref.: MFG, 2003). The net effect of the barrier will be a reduction in the total site groundwater pumping rate and the volume of groundwater to be treated.

The barrier technology evaluated for the MPA consists of a soil-bentonite slurry wall installed to depths commensurate with the bottom of the alluvial aquifer (~50-60 ft-bgs to bedrock) at the SWMU or SWMU Group. A slurry wall is expected to be more effective than a steel sheet wall based on a preliminary assessment of subsurface conditions at the site. See the Sheet Pile Containment Barrier evaluation for SWMU Group A (Section 6.2.3). This concept is designed to isolate the MPA and the associated groundwater zone beneath the MPA.

The slurry wall is constructed by excavating a trench that is filled with a bentonite slurry. The slurry hydraulically supports the trench to prevent collapse and forms a filter cake on the trench walls to reduce groundwater flow. The trench is backfilled with the excavation spoils that are blended with additional bentonite to form the complete barrier wall. If the excavated spoils are not free of contaminants, they would not be useable for a trench backfill. Clean fill material would need to be imported for backfill, and the spoils would be assumed to be taken offsite for disposal at a RCRA Hazardous waste landfill.

The area within SWMU Group B requiring the slurry wall barrier is estimated to cover approximately 10.5 acres and the wall length is estimated to be 2600 ft. The area within SWMU Group C requiring the slurry wall barrier is estimated to cover approximately 10.5 acres and the wall length is estimated to extend 1500 ft. The area within SWMU Group D requiring the slurry wall barrier is estimated to extend 4600 ft.

For a maximum barrier depth of ~60 feet, the wall could be constructed with a large excavator. These excavators have been used for trenches up to 100 feet in depth. A working platform approximately 50-100 feet wide is required for trench construction. The relatively flat topography in the MPA makes it possible to construct the wall in a continuous trench. Support facilities would include water and bentonite storage systems, a slurry mix plant and a materials unloading area. These facilities would most likely be located in a temporary support zone on top of the south landfill. See **Figure 3-2** for the SWMU locations.

The evaluation of Containment Barriers is described in the following sections.

6.3.4.2 MAIN PLANT SWMUs – SLURRY WALL EVALUATION SUMMARY

Slurry wall construction is impractical to implement within the MPA.

- SWMUs 21 and 27 are very small and not candidates for a slurry wall
- SWMU Group B contains the Bayer Plant wastewater and storm water storage and treatment facilities.
- SWMU Group C contains some smaller open SWMUs (8, 9 and 11). SWMU 7 is a 4 acre area that includes the incinerator facilities and the fuel oil storage tank
- SWMU Group D contains an elongated former wastewater trench (2250 LF running through the Plant (SWMU 10); SWMU 12 (10 ft. X 30 ft.); SWMU 15 10 ft. X 30 ft.); and SWMU 16 (12 ft. X 12 ft).

In addition, the costs for a slurry wall encompassing MPA SWMUs is very high. The engineering cost estimate summary for the slurry wall containment barrier Corrective Action technology is presented in **Table 6.3-3**.

SWMU Group/SWMU	Long-term Effectiveness	Reduction of Toxicity, Mobility and Volume	Short-term Effectiveness	Implementability	Costs	Community Acceptance	State Acceptance	Overall Numerical Ranking	Selected for SWMU or SWMU Group
B,C,D,21,27	n/a	n/a	n/a	n/a	High	n/a	n/a	**n/a**	**No**

6.3.5 INSITU CHEMICAL OXIDATION (ISCO)

6.3.5.1 DESCRIPTION

In-situ chemical oxidation (ISCO) has been identified as a potential Corrective Action technology for the MPA. Research indicates that oxidants such as sodium persulfate, iron-catalyzed hydrogen peroxide (Fenton's Reagent), and hydroxide-catalyzed persulfate provide significant reductions in soil VOC and SVOC constituents.

The ISCO remediation approach for the MPA is based on injection of liquid chemical oxidant solution using activated (i.e. via catalyst) sodium persulfate. Multiple successive injection events (i.e. two (2) events) were assumed to improve the dispersion of the ISCO material through the treatment zone. Direct-push injection methods will be used. General design parameters are as follows:

- Treatment zone is approximately 5 to 15 ft-bgs over the MPA. Total area for the MPA to be addressed is approximately 9-acres (not including tanks and buildings). See ISCO area in **Figure 3-2**;
- Direct push ISCO injection point spacing is on 10 ft centers (1/100 sf);
- Oxidant dosing at 0.5-1.0 % (5-10 g/kg soil, on a dry weight basis). Total oxidant proposed is estimated at 0.5% dry weight of soil, which equates to approximately 1000 tons at SWMU Group B, 420 tons at SWMU Group C; 310 tons at SWMU Group D, 17 tons at SWMU 21, and 4 tons at SWMU 27.
- Sodium persulfate pricing is assumed at $1.20/lb, with the material being delivered to the site in supersacks;
- Catalyst concentration is approximately 200 mg/l as Fe^{+2}-EDTA;
- Oxidant injection is approximately 250 kg/boring/event; and
- Two oxidant injections per boring in successive events, with the second event to follow shortly after the evaluation of the Phase I monitoring.
- Pilot-scale field tests over a sub area of the subject SWMU (minimum 400 sf) to assess oxidant delivery methods, dosage and treatability.

Bench-scale testing is recommended to determine the treatability of soils containing TDI residue material.

6.3.5.2 APPLICATION TO MPA SWMUS

Applications concerns and issues for ISCO technology in MPA are as follows:

➢ "The two most critical success factors in all ISCO projects are the effective distribution of reagents in the treatment zone and the reactivity of a particular oxidant with the contamination present. This combination requires careful site characterizations, screening and feasibility testing. Failure to account for subsurface heterogeneities or preferential flow paths can cause an uneven distribution of the oxidant, resulting in pockets of untreated contaminants … Low-permeable soils and subsurface heterogeneity offer a challenge for the distribution of injected fluids" (Technical and Regulatory Guidance for In Situ Chemical Oxidation of Contaminated Soil and Groundwater, Second Edition, January 2005, prepared by the ITRC).

- ISCO technology utilizes strong, non-selective oxidants in the unsaturated and saturated zones. Any area that contains structural fill composed of organic components (such as TDI residues and other wastes) is not a candidate for this technology on a wide scale because of the potential for structural degradation. SMWU Group B (SWMUs 4 & 5) contains significant TDI residues. ISCO requires close spacing of injection points and multiple injections. Active operating areas, such as the SWMU Group B lagoons and basins, are not good candidates. Therefore, SWMU Group B is not considered a candidate for ISCO.
- Because ISCO is not a selective oxidation process, very high dosages may be required in some areas with mixed wastes before the target COI is affected.
- In any mixed waste area, there is a potential for by-products with equal or worse characteristics than the target COIs may exhibit.
- Bench and pilot scale studies are required prior to wide-scale use.

The MPA (exclusive of SWMU Group B) exhibits generally similar chemical characteristics with respect to VOC and SVOC constituents that may make them amenable for ISCO technology. The dominant compounds, based on their concentration in soils and their potential for leaching to groundwater, are the nitroaromatics, TDA and VOCs benzene and chlorobenzene.

<u>SWMU Group C COIs</u>:

- VOCs- benzene, chlorobenzene toluene (all in SWMU 8 only) and trichloroethylene
- SVOCs- 1,2- dichlorobenzene, 1,4- dichlorobenzene, 2,4- dinitrotoluene, 2,6-dinitrotoluene, phenol and p-chloroaniline.

<u>SWMU Group D COIs</u>:

- SWMU 10: VOCs 1, 1- DCE, SVOCs 2,4- dinitrotoluene and 2,6- dinitrotoluene
- SWMU 12: benzene, chlorobenzene, toluene, nitrobenzene, dichlorobenzenes, p-chloroaniline.

SWMU 21 COIs:

- VOCs- benzene and toluene
- SVOCs- nitrobenzene, 2,4- dinitrotoluene, 2,6- dinitrotoluene, and p-chloroaniline.

SWMU 27 COIs:

- VOCs- benzene, toluene and TCE
- SVOCs- nitrobenzene, 2,4- dinitrotoluene, 2,6- dinitrotoluene, and bis (2-chloroethyl) ether.

Tiered Technology Demonstrations (TTD)

Because of the uncertainties in the effectiveness and implementation of ISCO within the MPA, it is recommended that a tiered technology demonstration program be implemented to evaluate the feasibility of ISCO remediation at the Site. This program would involve a series of technology demonstrations to test whether hot spot removal reduces groundwater contamination at selected SWMU hotspot areas throughout the MPA that best represent site conditions. The proposed program includes the following:

- Up to four (4) demonstration areas in the MPA conducted over a total 5 to 10-year period.
- Each area would involve an ISCO pilot test, nominal 10,000 ft^2 area, in selected SWMU areas throughout the plant that are most practically representative of Site conditions. The proposed test areas include SWMU 27, SWMU 21 and (2) other SWMU “hot spots”.
- Future ISCO actions, including potential full-scale applications in the MPA, would be based on the results of the technology demonstrations.

Implementation of the technology demonstration program would provide site-specific data on the feasibility of ISCO at the site, and would also provide design data for estimating oxidant suitability, optimum dosage rates, application methods, and monitoring protocols.

The tiered technology demonstration program is proposed as an alternative approach to full-scale implementation of ISCO within the MPA. The first step in the tiered approach is bench testing to determine whether all target contaminants are compatible with the selected oxidant. As such, costs for the ISCO demonstration program are independent of the full-scale ISCO costs for the CMS. The full-scale ISCO costs estimates are not provided herein due to the associated uncertainties. Site Corrective Measures that will include ISCO will be proposed with the tiered technology demonstration program and the costs will be included for the scope of the demonstration program as described herein.

The evaluation of ISCO is described in the following sections.

6.3.5.3 Long-term Effectiveness (Moderate – 1)

- ➢ Potentially effective for groundwater and soils with organic contaminants Care must be taken in the design and installation of these systems to minimize unintended effects such as generation of excessive heat and off-gases.
- ➢ Heterogeneous nature of the subsurface materials in some of the MPA SWMUs raises the concern for potential fill degradation leading to structural issues.
- ➢ Multiple injection actions may be required
- ➢ Potential for alternative COIs to be produced.

6.3.5.4 Reduction of Toxicity, Mobility or Volume (Moderate – 1)

- ➢ ISCO is effective in reducing toxicity, mobility and volume of organic contaminants.
- ➢ Limited demonstrated field applications for nitroaromatic compounds.

6.3.5.5 Short-term Effectiveness (Moderate – 1)

- ➢ Contaminant reductions are obtained in relatively short amount time
- ➢ Precautions required to prevent exposure of the strong oxidizing reagents to workers
- ➢ Precautions required to minimize potential oxidation-induced effects such as the generation of excessive heat and off-gases.

6.3.5.6 Implementability (Difficult – 0)

- ➢ Operating site with multiple interferences (tanks, buildings, piping) in MPA for insitu technologies such as ISCO
- ➢ The heterogeneous and low permeability nature of the subsurface materials would require a large number of injection points to complete the remediation and presents a technical challenge for efficient distribution of reagents.

6.3.5.7 Costs (High – 0)

The engineering cost estimate summary for the ISCO Corrective Action technology, as tiered technology demonstrations, is presented in **Table 6.3-4**.

<u>Capital</u>

Direct and indirect capital costs have been estimated for the implementation of this Corrective Action technology. Major cost components for this technology include:

- Engineering (@ 12.5% capital costs),
- Construction management (@ 8% capital costs),

- Direct push ISCO injection point spacing is on 20 ft centers (1/400 ft^2) for SWMU Groups C, D and SWMUs 21 and 27. Oxidant dosing at 0.5-1.0 % (5-10 g/kg soil, on a dry weight basis),
- Total oxidant proposed is approximately 1000 tons (0.5% dry weight). Sodium persulfate pricing is assumed at $1.20/lb (2006 US$), with the material being delivered to the site in supersacks, and
- Four (4) new monitoring wells in the alluvial aquifer at the POC.

OPERATION AND MAINTENANCE

Long-term O&M costs assuming thirty (30) years of O&M have also been estimated for the implementation of this Corrective Action technology, because the groundwater at the Site will likely remain impacted for a period of time following the completion of the ISCO treatment. Groundwater monitoring would need to be completed both in and around the test SWMUs to evaluate the effectiveness of the ISCO treatment and the potential long-term impact on Site-wide Groundwater. Performance monitoring is estimated for a 5-year period.

- Annual groundwater monitoring (VOCs, SVOCs, metals),
- Annual data evaluation and reporting,
- Monitoring well replacement (20%/5 years),
- Recovery well operation and perched water collection for 5 years (@5% capital costs/year) are required. Costs are addressed in Section 6.5, and
- Groundwater treatments for 5 years (@ $1.00/1000 gallons) are required. Costs are addressed in Section 6.5.

6.3.5.8 COMMUNITY ACCEPTANCE (High – 2)

➢ No concerns expected.

6.3.5.9 STATE ACCEPTANCE (Moderate – 1)

➢ May also require the procurement of a Class V UIC Permit-by-Rule.

➢ Must demonstrate both the effective of ISCO in addressing the COIs and that no other contaminants are formed.

6.3.5.10 MAIN PLANT AREA SWMUS – INSITU CHEMICAL OXIDATION EVALUATION SUMMARY

ISCO was evaluated for the seven criteria and were scored based on the evaluation. The evaluation results are summarized below:

SWMU Group/SWMU	Long-term Effectiveness	Reduction of Toxicity, Mobility and Volume	Short-term Effectiveness	Implementability	Costs	Community Acceptance	State Acceptance	Overall Numerical Ranking	Selected for SWMU or SWMU Group
B	n/a	n/a	n/a	n/a	n/a	n/a	n/a	**n/a**	**No**
C, D	Moderate 1	Moderate 1	Moderate 1	Difficult 0	High 0	High 2	Moderate 1	**6**	**Yes (TTD)**
21	Moderate 1	Moderate 1	Moderate 1	Moderate 1	High 0	High 2	Moderate 1	**7**	**Yes (TTD)**
27	Moderate 1	Moderate 1	Moderate 1	Moderate 1	Low 1	High 2	Moderate 1	**8**	**Yes (TTD)**

6.3.6 IN-SITU BIOLOGICAL TREATMENT (ISB)

6.3.6.1 DESCRIPTION

In-situ biological treatment (ISB) has been identified as a potential Corrective Action technology for the MPA. The MPA exhibit generally similar chemical characteristics with respect to VOC and SVOC constituents. The dominant compounds, based on their concentration in soils and their potential for leaching to groundwater, are the nitroaromatics, TDA and VOCs benzene and chlorobenzene. Metals cadmium, chromium and nickel were also present above SSLs in some of the SWMUs.

The selected biotechnology would involve anaerobic in-situ treatment using an enhanced process to create a reducing environment for indigenous microorganisms. In effect, a carbon source is injected into the groundwater aquifer that provides an energy source for indigenous microorganisms. As carbon is consumed, oxygen is depleted until the system becomes anaerobic allowing anaerobic fermentation that produces hydrogen gas. The hydrogen gas is consumed in competing reactions – reduction of electron acceptors and reduction of nitroaromatics.

Hydrogen donor materials are commercially available to facilitate and induce the in-situ anaerobic biodegradation of chlorinated hydrocarbons. Both agents have had many deployments for this type of in-situ treatment. Recently, the U.S. Army Corps of Engineers (USACE) conducted a field treatability study at the former West Virginia Army Ordnance Works in Point Pleasant, WV on nitroaromatic impacted soils. The USACE concluded that the use of this Corrective Action technology provided a cost-effective means of treating the soils at this site.

Bench-scale and pilot studies of explosives-contaminated groundwater treatment by reductive biotransformation have been performed at the U.S. Army Pueblo Chemical Depot in Colorado. Contaminants with similarities to the Bayer site COIs included dinitrotoluenes (DNT), trinitrobenzenes (TNB) and trinitrotoluenes (TNT). A proprietary hydrogen donor material (Regenesis HRC) was used to treat groundwater containing the explosives constituents. The results of the lab studies showed that >95% reductions were obtained for most of the constituents in less than 30 days. Pilot studies indicated that site-specific action levels were achieved for all compounds within 106 days. Additionally, biodegradation by-products, including nitrates, were not found to accumulate in groundwater, and were also removed by the treatment.

The ISB remediation approach for the MPA is based on injection of solubilized hydrogen donor materials using a commercially available product. A single injection event was assumed for cost estimating purposes, but multiple successive injection events may be required to improve the dispersion of the ISB material through the treatment zone. Direct-push injection methods will be used. General design parameters are as follows:

- Treatment zone is approximately 5 to 15 ft-bgs over an area of approximately 9-acres (not including tanks and buildings). See ISB area in **Figure 3-2**;
- Direct push ISB injection point spacing is on 10 ft centers (1/100 sf);
- ISB dosing at between 82 and 820 lbs of hydrogen donor material per cubic yard of soil (2-20%, by weight). Further quantification of actual dosing quantities will be accomplished following the completion of treatability testing. For the purposes of cost estimating the low end value of 2% (4000 tons) will be assumed;
- ISB donor material pricing is assumed at $2.00/lb, with the material being delivered to the site; and
- Treatability testing will be required to determine the most appropriate dosing level and these costs are estimated at approximately $15,000.

Remediation performance monitoring will be required for baseline and post-treatment conditions within the treatment zone soils and local perched water. Monitoring is proposed following the injection event.

It is assumed that the Site-wide Groundwater pumping, containment and treatment system will remain in operation during the implementation and performance monitoring period. Groundwater recovery and treatment are described in Section 6.5 and their associated capital costs are not included in this technology cost.

Caps/covers are *not assumed* to be used in conjunction with ISB since the intent of the treatment is waste constituent destruction.

<u>Tiered Technology Demonstrations (TTD)</u>

Because of the uncertainties in the effectiveness and implementation of ISB within the MPA, it is recommended that ISB be evaluated for incorporation into a tiered technology demonstration program to determine the feasibility of ISB remediation at the Site. This program would involve a technology demonstration test at selected MPA SWMU hotspot areas. It is proposed that the TTD program be conducted as following:

- The proposed potential test area is SWMU 27.
- The test area to involve ~ 10,000 ft^2 area within SWMU 27.

Implementation of the TTD would provide site-specific data on the feasibility of ISB at the site, and would also provide design data for estimating oxidant suitability, optimum dosage rates, application methods, and monitoring protocols.

The TTD is proposed as an alternative approach to full-scale implementation of ISB within the MPA. Costs for the ISB TTD have been developed (**Table 6.3-5**). Full-scale ISB costs estimates cannot be determined with any degree of certainty. Site Corrective Measures alternatives that may include ISB will be proposed as TTD and the costs associated with the TTD will be included.

The evaluation of ISB TTD is described in the following sections.

6.3.6.2 LONG-TERM EFFECTIVENESS (Effective – 2)

- Effective Corrective Action technology for both soil and groundwater contaminated by organic constituents similar to the Bayer site. Expected to provide for long-term effectiveness by breaking down the COIs to less toxic by-products.
- Bench-scale treatability and/or pilot-scale studies within the MPA are required to facilitate the appropriate design, and confirm the most feasible ISB dosage and delivery method for the site conditions.

6.3.6.3 REDUCTION OF TOXICITY, MOBILITY OR VOLUME (Effective – 2)

- ISB would destroy the COIs with the expectations that leaching of COIs to groundwater would be reduced.
- Field pilot testing and performance monitoring under site subsurface conditions will provide data for reasonable predictions of groundwater improvement and associated costs.

6.3.6.4 SHORT-TERM EFFECTIVENESS (Moderate – 1)

- The biological degradation process occurs over a longer time frame than other more aggressive technologies.
- More discriminating approach with respect to destruction of the target compounds exclusively vs. more aggressive oxidative technologies.

6.3.6.5 IMPLEMENTABILITY (MODERATE – 1)

- Multiple injection actions may be required to assure treatment of the entire MPA to acceptable levels
- Heterogeneous nature of the soils requires a tightly spaced injection grid to effectively deliver the ISB materials to the soil matrix
- Presence of above-ground structures and underground lines adds to implementation difficulties.
- Potential for fill structural degradation as a result of TDI breakdown by biodegradation will need to be considered and assessed in the bench-scale testing.
- Injection would be primarily into the unsaturated zone, and sufficient liquid dispersion throughout the soil matrix would be required to distribute the hydrogen

donor material. Supplemental soil fracturing may be used to increase the distribution of donor liquids in the subsurface soils.

- Operating facilities (tanks, buildings, piping) will limit access to some areas.

6.3.6.6 COSTS (Low – 1)

The engineering cost estimate summary for the ISB Corrective Action technology as a TTD is presented in **Table 6.3-5**.

6.3.6.7 COMMUNITY ACCEPTANCE (High – 2)

- No concerns expected.

6.3.6.8 STATE ACCEPTANCE (High – 2)

- Acceptance of TTD expected.
- May require the procurement of a Class V UIC Permit-by-Rule

6.3.6.9 MAIN PLANT AREA SWMUS – IN- ITU BIOLOGICAL (ISB) TREATMENT EVALUATION SUMMARY

ISB was evaluated for the seven criteria and were scored based on the evaluation. The evaluation results are summarized below:

SWMU Group/SWMU	Long-term Effectiveness	Reduction of Toxicity, Mobility and Volume	Short-term Effectiveness	Implementability	Costs	Community Acceptance	State Acceptance	Overall Numerical Ranking	Selected for SWMU or SWMU Group
B	n/a	n/a	n/a	n/a	n/a	n/a	n/a	**N/E**	**No**
C, D	n/a	n/a	n/a	n/a	n/a	n/a	n/a	**N/E**	**No**
21	n/a	n/a	n/a	n/a	n/a	n/a	n/a	**N/E**	**No**
27	Effective 2	Effective 2	Moderate 1	Moderate 1	Low 1	High 2	High 2	**11**	**Yes (TTD)**

N/E – NOT EVALUATED

6.3.7 On-site Incineration (Bayer Facility)

6.3.7.1 Description

See **Section 6.2.9.1** for descriptions of site incineration facilities and limitations.

Based on site incineration facilities design, capacity, incinerator availability and operational encumbrances, on-site incineration is infeasible for all MPA SWMUs with the exception of SWMU 27(800 tons).

- Bayer incinerator lacks a mechanism to feed solids
- The large volume of waste material to be processed, approximately 392,000 tons, would take a total processing time of >100 years at 100% operations. SWMU 21 is also excluded from further consideration because of high waste volumes (6500 tons).
- Excavation of MPA SWMU Groups A, B and C, excluding SWMU 27, is impractical because of on-going operations and / or the presence of plant process basins and structural facilities.

The results of the evaluation of on-site incineration for SWMU 27 follow:

6.3.7.2 Long-term Effectiveness (Effective – 2)

- Removal is effective in meeting CAOs.

6.3.7.3 Reduction of Toxicity, Mobility or Volume (Effective – 2)

- Source of potential leaching of COIs to groundwater is removed.

6.3.7.4 Short-term Effectiveness (Moderate - 1)

- Removal over a relatively short period of time is expected.

6.3.7.5 Implementability (Difficult – 0)

- Moderately difficult for SWMU 27 based on limited capacity of site incineration
- At an estimated 50% of available capacity, processing of the SWMU 27 soils will take approximately 1 year.

6.3.7.6 Costs (Moderate – 1)

SWMU 27 has been estimated for the on-site incineration technology. The engineering cost estimate summary is presented **Table 6.3-6**.

6.3.7.7 Community Acceptance (Low –0)

- Concerns expected to permit additional on-site incineration capacity for hazardous wastes.

6.3.7.8 State Acceptance (Moderate – 1)

- Acceptance of TTD expected.
- Incineration and air permit modifications required.

6.3.7.9 MAIN PLANT AREA SWMUs – ON-SITE INCINERATION

On-site incineration was evaluated for the seven criteria and was scored based on the evaluation. The evaluation results are summarized below:

SWMU Group/SWMU	Long-term Effectiveness	Reduction of Toxicity, Mobility and Volume	Short-term Effectiveness	Implementability	Costs	Community Acceptance	State Acceptance	Overall Numerical Ranking	Selected for SWMU or SWMU Group
B,C,D, 21	n/a	n/a	n/a	n/a	n/a	n/a	n/a	**n/a**	**No**
27	Effective 2	Effective 2	Moderate 1	Difficult 0	Moderate 1	Low 0	Moderate 1	**7**	**Yes**

6.3.8 INCINERATION (OFF-SITE)

See **Section 6.2.10 Incineration – Off site** (SWMU Group A) for discussion on commercial offsite incineration capacity.

Based on site operational related facility constraints and waste volumes vs. commercial availability, off-site incineration is infeasible for all MPA SWMUs with the exception of SWMU 21 (6500 tons) and SWMU 27 (800 tons). Based on a typical RCRA incineration cost of $300/ton, incineration alone would cost an estimated $115,000,000. Significant additional costs would be incurred for excavation, waste preparation, transportation and site restoration. This technology has been eliminated from further consideration for SWMU Groups B, C and D because of the relatively high costs compared to other technologies.

The evaluation of Off-Site Incineration for SWMUs 21 and 27 follows.

6.3.8.1 LONG-TERM EFFECTIVENESS (Effective –2)

- Removal of the source of COIs eliminates the potential to leach to groundwater

6.3.8.2 REDUCTION OF TOXICITY, MOBILITY OR VOLUME (Effective –2)

- Effective in reduction of toxicity, mobility, and volume of COIs – eliminating the potential for COIs to leach to groundwater.

6.3.8.3 SHORT-TERM EFFECTIVENESS (Moderate–1)

- Off-site transportation issues will present potential exposures to operators and the community
- Commercial Incineration capacity will allow a target implementation schedule of < 5 years.

6.3.8.4 IMPLEMENTABILITY (Moderate –1)

- Difficult for SWMU 21 because of contiguous plant operating facilities.
- Moderately difficult for SWMU 27. The depth of excavation would be relatively shallow ~15ft-bgs, and would be maintained above the water table. Plant facilities and process piping within and adjoining the SWMU 27 area are limited.

6.3.8.5 COSTS (High –0)

SWMUs 21 and 27 have been estimated for this technology. The engineering cost estimate summary is presented **Table 6.3-7**.

6.3.8.6 COMMUNITY ACCEPTANCE (Moderate–1)

- Concerns expected based on local impacts from waste hauling over an extended period (> 1 year). For a typical highway load of 15 tons, a total of approximately 40 truckloads per month would be required.

6.3.8.7 STATE ACCEPTANCE (High –2)

- State/agency acceptance is expected.

6.3.8.8 MAIN PLANT AREA SWMUS – OFF-SITE INCINERATION EVALUATION SUMMARY

Off-site incineration was evaluated for the seven criteria and was scored based on the evaluation. The evaluation results are summarized below:

SWMU Group/SWMU	Long-term Effectiveness	Reduction of Toxicity, Mobility and Volume	Short-term Effectiveness	Implementability	Costs	Community Acceptance	State Acceptance	Overall Numerical Ranking	Selected for SWMU or SWMU Group
B,C,D	n/a	n/a	n/a	n/a	n/a	n/a	n/a	**n/a**	**No**
21, 27	Effective 2	Effective 2	Moderate 1	Moderate 1	High 0	Moderate 1	High 2	**9**	**Yes**

6.3.9 Off-site Landfilling

6.3.9.1 Description

Off-site landfilling is a potentially applicable ex-situ Corrective Action technology for the MPA SWMUs. RCRA commercial waste disposal facilities are anticipated for disposal.

See Section **6.2.11.1 Off-Site Landfilling** (SWMU Group A) for a discussion on commercial off-site hazardous landfill capacity availability.

Based on site operational related facility constraints and waste volumes vs. commercial availability, off-site landfilling is infeasible for all MPA SWMUs with the exception of SWMU 21 (6500 tons) and SWMU 27 (800 tons). In addition, based on a typical RCRA landfill cost of $150/ton, landfilling of hazardous wastes (RCRA-listed) would cost an estimated $57,750,000 for the 390,000 tons of waste in MPA SWMU Groups B, C and D. Significant additional costs would be incurred for excavation, waste preparation, onsite treatment, transportation and site restoration. This technology has been eliminated from further consideration for SWMU Groups B, C and D because of the relatively high costs compared to other technologies.

The evaluation of Off-Site Landfilling for SWMUs 21 and 27 follows.

6.3.9.2 Long-term Effectiveness (Effective –2)

- Very effective since source of the COIs is removed from the Site.

6.3.9.3 Reduction of Toxicity, Mobility or Volume (Effective –2)

- Removal of the COIs is effective in reducing toxicity, mobility and volume and thereby reduce the potential for COI leaching to groundwater.

6.3.9.4 Short-term Effectiveness (Moderate –1)

- Commercial disposal capacity availability is critical to removal and is expected to be limiting removal rates.
- For an estimated 1 year period to remove the material from SWMUs 21 and 27 (totaling 7300 tons), the average waste removal rate would be approximately 150 tons per week. During this time there would be an increased potential for environmental releases, exposure to the community and exposure to site workers.

6.3.9.5 Implementability (Moderate –1)

- SWMU 21 has operations related encumbrances and excavation concerns.
- SWMU 27 is more open and easier to excavate from an operations concern easy to implement.

6.3.9.6 Costs (High –0)

SWMUs 21 and 27 have been estimated for this technology – see **Table 6.3-8**.

6.3.9.7 Community Acceptance (Moderate –1)

- Some community concerns expected based on local impacts from waste hauling over an extended period and the potential for exposure to the community.

6.3.9.8 State Acceptance (High –2)

- State/agency acceptance is expected.

6.3.9.9 Main Plant Area SWMUs – Offsite Landfilling Evaluation Summary

Offsite landfilling was evaluated for the seven criteria and was scored based on the evaluation. The evaluation results are summarized below:

SWMU Group/SWMU	Long-term Effectiveness	Reduction of Toxicity, Mobility and Volume	Short-term Effectiveness	Implementability	Costs	Community Acceptance	State Acceptance	Overall Numerical Ranking	Selected for SWMU or SWMU Group
B,C,D	n/a	n/a	n/a	n/a	n/a	n/a	n/a	**n/a**	**No**
21, 27	Effective 2	Effective 2	Moderate 1	Moderate 1	High 0	Moderate 1	High 2	**9**	**Yes**

6.3.10 Corrective Measures Alternative Ranking Summary – MPA SWMUs

Table 6.3-9 presents a summary of the non-discounted direct/indirect capital costs, O&M (annual) costs, and associated periodic costs for each of the evaluated Corrective Action technologies for MPA SWMUs for comparative purposes. **Table 6.3-10** presents a summary of the present value calculations for the evaluated Corrective Action technologies for MPA SWMUs.

The table below summarizes MPA technologies carried forward to **Section 7.0** for incorporation into Site Corrective Measures Alternatives.

Section 6.3 MPA SWMU Technology Evaluation Results Summary	
Technology	***SWMU Specific Application***
Institutional Controls	**Retained**
Covers/Caps (Soil, pavement and/or synthetic membranes)	**Retained SWMU 27**
Containment Barriers (Sheet piles, slurry walls, synthetic membranes)	**X**
Passive Treatment Walls [Vertical walls constructed by trenching and/or injection.]	
Zero-valent iron (ZVI)	
Biosparging	
In-Situ Treatment	
In-situ Chemical Oxidation (ISCO)	**Retained TTD [Groups C & D] [SWMUs 21, 27]**
In-situ Biological (ISB) [Aerobic and/or Anaerobic]	**Retained TTD – SWMU 27**
Chemical Flushing	
Soil Vapor Extraction (SVE)	
Enhanced SVE (In-situ thermal desorption by resistance and/or RF heating)	
Stabilization	
Ex Situ Treatment/Disposal [Assumes removal by excavation and/or pumping]	
On-site Incineration (Bayer Facility)	**Retained SWMU 27**
Off-site Incineration	**Retained SWMUs 21, 27**
Thermal Desorption	
Biopiles / Landfarming	
Soil Washing	
Off-site Landfill	**Retained SWMUs 21, 27**
Groundwater Treatment	
Enhanced Site-wide Groundwater Containment and Treatment	**Retained**
Natural Attenuation	
Trenches and/or Recovery Wells (Perched water collection)	

X – Evaluated and eliminated from further consideration

6.4 SITE-WIDE GROUNDWATER

The alluvial aquifer is described in detail in Section 3.0, Summary of Current Conditions, and other reports referenced in that section of the CMS.

6.4.1 CAOS FOR SITE-WIDE GROUNDWATER

The RFI and site-specific risk assessment concluded the following with respect to Site-wide Groundwater:

- Site-wide Groundwater contains COIs in excess of their respective MCLs.
- Site-wide Groundwater does not represent a current risk to human health or the environment.
- Current Corrective Measure - pump and treat for Site-wide Groundwater, provides hydraulic containment of the COI plume, preventing the off-site migration of dissolved phase COIs.
- Site-wide Groundwater should be addressed in a CMS to evaluate available technologies to expedite groundwater restoration.

The Site-wide Groundwater CAOs as discussed in **Section 4.0** are as follows:

- Prevent unacceptable human exposures to recovered contaminated groundwater,
- Maintain current groundwater recovery well system operation for groundwater collection and plume hydraulic containment within the Site boundary, and
- Provide for the continued control of potential off-site migration of contaminated groundwater to a level that is protective of surface water quality.
- Implement reasonable efforts to eliminate or mitigate further releases of contaminants from Site SWMUs (using the site boundary as the point of compliance).
- Reduction of contaminant levels, as practicable, over time to support reasonably expected use.

6.4.2 *MEDIA- SPECIFIC CLEANUP GOALS*

Specific goals for Site-wide Groundwater were discussed in detail in **Section 4.1 Media Specific Cleanup Goals**. Summarizing from Section 4.1:

The proposed "media cleanup level" for Site groundwater is as follows:

- Site related COI concentrations = their respective MCL and WV Surface Water Quality Standard at the POC (Site Boundary).

When containment is part of the final remedy, facilities and regulators should develop systems to monitor the effectiveness of the containment (Handbook of Groundwater Protection and Cleanup Policies for RCRA Corrective Action, Final Cleanup Goals, pg. 4.6). Therefore, the following criteria are proposed as measures of effectiveness of the containment element of the Final Remedy:

- Periodic confirmation that no Site related COIs have reached the drinking water wells of any potential receptors.
- Periodic documentation of an inward gradient for the alluvial aquifer at the Site boundary.

6.4.3 SITE-WIDE GROUNDWATER TECHNOLOGIES FOR EVALUATION

The technologies identified for Site-wide Groundwater that remained after the screening step are summarized in **Table 5-24** and are summarized below:

Site-Wide Groundwater - Improvement Technology Screening Summary	
Technology	***Screening Result***
Institutional Controls	**Retained**
Covers/Caps (Soil, pavement and/or synthetic membranes)	
Containment Barriers (slurry wall)	**Retained**
Passive Treatment Walls [Vertical walls constructed by trenching and/or injection.]	
Zero-valent iron (ZVI)	
Biosparging	
In-Situ Treatment	
In-situ Chemical Oxidation (ISCO)	
In-situ Biological (ISB) [Aerobic and/or Anaerobic]	**Retained**
Chemical Flushing	
Soil Vapor Extraction (SVE)	
Enhanced SVE (In-situ thermal desorption by resistance and/or RF heating)	
Stabilization	
Ex Situ Treatment/Disposal [Assumes removal by excavation and/or pumping]	
On-site Incineration (Bayer Facility)	
Off-site Incineration	
Thermal Desorption	
Biopiles / Landfarming	
Soil Washing	
Off-site Landfill	
Groundwater Treatment	
Enhanced Site-wide Groundwater Containment and Treatment	**Retained**
Natural Attenuation	
Trenches and/or recovery wells – SWMU Group A Perched water Collection	

Each of these technologies has been evaluated using the seven (7) criteria previously described in Section 6.1. Following the completion of the detailed evaluation, the individual Corrective Action technologies were ranked by assigning a numeric factor to the criteria to obtain an overall evaluation score for the technology. Final recommendations for Corrective Measures alternatives for overall site implementation are described in Section 7.0.

In the following sections, potential Corrective Action technologies have been evaluated for Site-wide Groundwater to meet the Site CAOs related to groundwater and Site Groundwater clean-up goal.

6.4.4 INSTITUTIONAL CONTROLS

6.4.4.1 DESCRIPTION

Institutional controls (ICs) are designed to prevent human exposures groundwater contaminants over both the short and long-term periods. ICs are currently in place to address onsite wastewater treatment of recovered groundwater. Final ICs could include:

- Plant safety plan descriptions of Site-wide Groundwater with safety protocols and restrictions for working within or near groundwater,
- Hazard communication plan for worker activities potentially exposed to groundwater, including periodic worker and contractor training as necessary, with a general plant facility plan and mapping notations for the groundwater conditions for reference purposes,
- Deed restrictions and/or recordation with Miss Utility of West Virginia. The use of deed restrictions will be applicable if the current land use changes at some point in the future, as any deed restrictions will run with the land.

This cost estimate is presented in **Table 6.4-1**.Based on the general acceptance of the need and benefits of ICs in general, this technology will be carried forward into Section 7.0 for incorporation into Site-wide Alternatives.

6.4.5 SITE-WIDE CONTAINMENT BARRIER- SLURRY WALL

6.4.5.1 DESCRIPTION

The implementation of a low permeability, vertical containment barrier is a potentially applicable Corrective Action technology for Site-wide Groundwater. The purpose of the barrier is to reduce/eliminate the lateral migration potential of dissolved phase constituents into the surrounding surface water bodies, primarily the Ohio River. The slurry wall would be used as a primary groundwater migration control mechanism as an alternative to the existing Site-wide Containment and Treatment system. However, long-term groundwater dewatering from within the containment area would still be required to maintain an inward hydraulic gradient to the containment cell area.

Currently, contaminated groundwater is hydraulically contained by the site recovery well system (MFG, 2003). The average pumping rate of the recovery well system over the last 5 years has been reported to be 474 gpm (MFG, 2003). The net effect of the containment barrier would be a reduction in the total site groundwater pumping rate, and the volume of groundwater to be treated. Groundwater dewatering within the containment cell and onsite treatment and monitoring are included in this alternative. Four new monitoring wells are included in the cost estimate

The barrier technology evaluated consists of a soil-bentonite slurry wall installed to depths commensurate with the bottom of the alluvial aquifer (~50 ft-bgs to bedrock). A slurry wall is expected to be more effective than a steel sheet wall based on a preliminary assessment of subsurface conditions at the site. See the Sheet Pile Containment Barrier evaluation for SWMU Group A (Section 6.2.3). The slurry wall is constructed by excavating a trench that is filled with bentonite slurry. The slurry hydraulically supports the trench to prevent collapse and forms a filter cake on the trench walls to reduce groundwater flow. The assumption for this analysis is that the trench is backfilled with the excavation spoils that are blended with additional bentonite to form the complete barrier wall. If the excavated spoils are not free of contaminants, they would not be useable for a trench backfill. Clean fill material would need to be imported for backfill, and the spoils would be assumed to be hauled offsite for disposal at a RCRA Hazardous waste landfill at considerable costs. Evaluation of the SWMU Group A landfill under a RCRA Corrective Action Management Unit (CAMU) designation may enable the spoils to be placed onsite in the landfill could neutralize some of those costs.

The Site-wide Groundwater slurry wall barrier length required to contain the site is estimated to be 13,000 ft. For a maximum barrier depth of ~60 feet, the wall could be constructed with a large excavator. These excavators have been used for trenches up to 100 feet in depth. A working platform approximately 50-100 feet wide is required for trench construction. The SWMU Group A topography varies and would require additional construction measures as described in Section 6.2.4.

6.4.5.2 CONTAINMENT BARRIER (SLURRY WALL) INFILTRATION ANALYSES

An estimate of the net water inflow to the containment area has been made in order to define the cost of dewatering and water treatment operations. The main components of inflow to the containment cell area are: rainfall infiltration, barrier leakage and bedrock leakage.

The net infiltration into the site-wide area has been estimated assuming current mixed cover conditions. For capped areas, rainfall infiltration would be assumed to be negligible. For the Site, the net infiltration is estimated to be 5 inches per year. Over an estimated containment area of approximately 130-acres, the annual water volume would be 650 acre-inches, or approximately 17.6MM gallons. The average flow rate would be approximately 33.6 gpm.

The slurry wall to bedrock will not provide complete isolation of the groundwater. The rate of leakage has been calculated based on a range of bedrock permeability and seepage zone thicknesses. The site-wide containment area seepage rates are estimated to range from 89.2 to 167 gpm.

Groundwater removal from within the containment barrier is included in this measure. The level of internal drawdown is estimated to be at elevation 600 ft (H2) to maintain an inward hydraulic gradient. It is also assumed that the existing groundwater removal/treatment system will be in operation and will allow treatment of pumped groundwater. This alternative will include the costs for treating the total estimated seepage through the containment system as an alternative to the existing groundwater recovery system. This total inflow (and average pumping rate) is estimated at 162 gpm (1.0 safety factor) for cost evaluation purposes.

6.4.5.3 EVALUATION OF SLURRY WALL CONTAINMENT BARRIER FOR SITE-WIDE GROUNDWATER

The evaluation of the seven criteria for a slurry wall Containment Barrier for Site-wide Groundwater condenses down to two overriding issues: Implementability and Cost, which is related to implementability.

6.4.5.3.1 IMPLEMENTABILITY

The constructability of a slurry wall around the perimeter of the Site is very difficult to impractical in this operating facility (See Figure 3.2 and 3.3). Some of the issues that would need to be overcome include:

- Constructing a slurry wall to bedrock within feet of the Ohio River is possible but very difficult.

  The western boundary of the Site is very near the railroad and the Ohio River. The proposed slurry wall alignment is intersected by underground utility and process as well as overhead obstructions. Avoiding the railroad and Site related obstructions in the alignment pathway forces the alignment very near the Ohio River. Water intrusion into the trench excavation for the slurry wall would pose a difficult and expensive engineering and construction challenge.

- Operating process facilities along most of the proposed barrier alignment severely limits the constructability of the barrier. Sufficient undeveloped property areas are not currently available beyond the plant operations to allow unrestricted construction of a barrier.
- Site utilities and process piping and communications infrastructure.
- Property access along the western side of the barrier would involve railroad right-of-way issues.

6.4.5.3.2 COSTS

Ignoring most of the unknowns mentioned in the "implementability" discussion, an engineering cost estimate has been developed using standard costing software. This result ($15.7MM Capital) is presented in detail in **Table 6.4-2**. However, the cost to deal with the implementability issues is not determinable with standard software at present. Consequently, the uncertainty in the estimated cost to implement this technology is 100% or more.

6.4.5.3.3 ALLUVIAL AQUIFER SLURRY WALL – EVALUATION SUMMARY

A slurry wall barrier for the Site-wide Groundwater is not practical from an implementability or cost standpoint. In addition, a perimeter barrier will still require a significant pump and treat element to remove water which leaks into the site and insure an inward gradient and to manage surface infiltration over the assumed 130 acres of contained area. At this point in the analysis, it is clear that there are other equally time tested technologies such as hydraulic containment via groundwater extraction wells that are more practical, more cost effective and capable of achieving Site-wide Groundwater CAOs.

6.4.6 IN-SITU BIOLOGICAL TREATMENT

6.4.6.1 DESCRIPTION

In-situ biological treatment (ISB) involves the use of indigenous microorganisms to biodegrade the organic constituents in the groundwater. Biotreatment by direct injection of anaerobic biosupplements is evaluated for Site-wide Groundwater. The typical system uses injected reagents, such as methanol, molasses, sodium lactate, methane and hydrogen gas and other electron donor materials, including vendor-supplied proprietary agents.

Biotreatment technology has been shown to be effective in treating petroleum hydrocarbons, VOCs and some of the other organics present in the main plant alluvial groundwater. As indicated for Insitu Biotreatment of site MPA SWMUs, (ISB Section 6.3.5), nitroaromatics have been found to be successfully treated by anaerobic degradation by direct injection of biosupplements.

The biotreatment system evaluated for Site-wide Groundwater involves injection of liquid biosupplements into the groundwater in "up-gradient" perimeter locations to enhance anaerobic degradation of the groundwater constituents. Contaminated groundwater would be treated by microorganisms established within and around the treatment zone and the groundwater would flow under pumping conditions. The most cost-effective biosupplement and nutrient requirements and the site-specific design, will require bench-scale testing with actual site groundwater. The effectiveness of anaerobic biotreatment for groundwater would also be determined from bench-scale testing. The limiting design factor is generally the constituent with the lowest degradation rate and the required residence time within the treatment zone. The groundwater hydraulic conditions affect the estimated contaminant residence time in the treatment zone and must be factored into the design.

The upgradient injection approach would enable the enhanced microbial zone to migrate toward the remaining areas of the aquifer, towards the center of the main plant to the recovery wells. Direct-push injection methods will be used. The plant perimeter area for injection purposes is assumed to be 13,000 feet long by 10 feet wide. General design parameters are as follows:

- Treatment zone is 40-70 ft-bgs (alluvial aquifer) over an area of approximately 130,000 ft2. See MPA in **Figure 3-2**;
- Direct push ISB injection point spacing is on 50 ft centers (1/500 sf) within the treatment zone;
- ISB dosing for the upgradient injection approach is between 40 and 400 lbs of hydrogen donor material per cubic yard of aquifer (1-10%, by weight). Further quantification of actual dosing quantities will be accomplished following the completion of treatability testing. For the purposes of cost estimating the low end value of 1% (~2900 tons) was assumed for the initial injection application;
- ISB donor material pricing is assumed at $2.00/lb, with the material being delivered to the site; and
- Treatability testing will be required to determine the most appropriate dosing level and these costs are estimated at approximately $15,000.

The following assumptions are made for the CMS evaluation of ISB:

- ➢ The existing recovery well system would be maintained at 474 gpm (Current average rate) to control offsite migration of contaminated groundwater during biotreatment implementation
- ➢ Source control actions at all or most of the SWMUs occur in addition to the Site-wide Groundwater ISB to address the source of the COIs. The cost of this source control is not included in this evaluation.
- ➢ For cost evaluations, only one (1) round of ISB treatment will occur. Multiple rounds are expected to be required.

The evaluation of ISB for Site-wide Groundwater is described in the following sections.

6.4.6.2 LONG-TERM EFFECTIVENESS (Moderate –1)

- ➢ ISB has proven to be an effective Corrective Action technology for groundwater contaminated by organic constituents. Recent field studies indicate that Site Groundwater COIs can potentially be treated be treated by ISB. (See Section 6.2.4)

- Multiple injection actions may be required to assure treatment of Site-wide Groundwater.
- Organic constituents in the groundwater other than Site COIs will compete for the ISB donor reagents. Most of the groundwater that the ISB reagents will see during pumping and treating of Site-wide Groundwater is water from the river. Whether ISB reagents can be developed which will specifically and preferentially address Site COIs vs. other organics in the soils and groundwater will need to be empirically determined.

6.4.6.3 REDUCTION OF TOXICITY, MOBILITY OR VOLUME (Moderate –1)

- Largely unknown because of the multiple effectiveness factors that can only be determined with Site testing
- ISB has been demonstrated to be an effective technology with respect to the reduction of the concentrations of COIs in groundwater in other environments. Testing is required to determine if the ISB is effective at the Bayer Site under Site-wide Groundwater site-specific conditions.

6.4.6.4 SHORT-TERM EFFECTIVENESS (LIMITED – 0)

- Potential Health and safety issues for Site workers associated with off-gas.
- ISB is not effective immediately in reducing the concentrations of COIs. Testing will be required to determine optimum reagents.
- The specificity of ISB reagents will need to be determined with bench and field experimentation.

6.4.6.5 IMPLEMENTABILITY (Moderate –1)

- Design considerations must be made for existing aboveground structures and any potential underground lines.
- Surface access to the injection points along the plant perimeter may be limited by plant facilities, however, angled injections can be performed to mitigate the surface obstruction concerns.
- Injection spacings of 50-100 feet are anticipated for the upgradient application approach.

6.4.6.6 COSTS (HIGH – 0)

The engineering cost estimate summary for the ISB Corrective Action technology is presented **Table 6.4-3**. The cost of ISB materials and implementation for one (1) round of ISB treatment is estimated to be in excess of $13 MM. The need for multiple rounds of treatment is anticipated.

6.4.6.7 COMMUNITY ACCEPTANCE (HIGH – 2)

- No concerns expected.

6.4.6.8 STATE ACCEPTANCE (Moderate – 1)

- State/agency concerns expected with respect to formation of undesirable by products
- ISB may require procurement of a Class V UIC Permit-by-Rule.

6.4.6.9 SITE-WIDE GROUNDWATER ISB – EVALUATION SUMMARY

ISB for Site-wide Groundwater is not an acceptable technology for incorporation into Site Alternatives based on the uncertainties of performance in the alluvial aquifer under high flow pumping conditions and the very high costs even assuming success with a limited number of injection rounds.

Site-wide Groundwater- Insitu Biotreatment	Long-term Effectiveness	Reduction of Toxicity, Mobility and Volume	Short-term Effectiveness	Implementability	Costs	Community Acceptance	State Acceptance	Overall Numerical Ranking	Selected for SWMU or SWMU Group
	Moderate 1	Moderate 1	Limited 0	Moderate 1	High 0	High 2	Moderate 1	7	No

6.4.7 Enhanced Site-wide Groundwater Containment and Treatment

6.4.7.1 Description

An enhancement of the existing groundwater recovery, treatment and hydraulic containment system was evaluated as an alternative to meet Site-wide Groundwater CAOs. Currently, contaminated groundwater migration is hydraulically contained by the site groundwater recovery well system (MFG, 2003). The average pumping rate of the recovery well system over the last 5 years is reported to be approximately 474 gpm (MFG, 2003).

The groundwater recovery well system consists of three wells, RW-1, RW-2 and RW-3, each screened across the entire saturated thickness of the alluvial aquifer. These three (3) groundwater recovery wells continuously pump groundwater in order to maintain a hydraulic capture zone for Site COIs that have been transported into the alluvial aquifer. Recovered groundwater is then processed through the existing wastewater treatment plant at the Site

For the Enhanced Site-wide Groundwater Containment and Treatment evaluation, two additional recovery wells are assumed to be installed to add more certainty that Site groundwater is hydraulically contained. The assumed site-wide pumping rate increase for cost estimating purposes is 300 GPM, or an assumed final pumping rate of 774 gpm for the Enhanced Site-wide Groundwater Containment and Treatment system.

The evaluation of the Enhanced Site-wide Groundwater Containment and Treatment system is described in the following sections.

6.4.7.2 Long-term Effectiveness (Effective –2)

The current recovery well pump and treat system has been proven to be effective in addressing all of the Site-wide Groundwater CAOs:

- Prevent unacceptable human exposures to recovered contaminated groundwater.
- Maintain current groundwater recovery well system operation for groundwater collection and plume hydraulic containment within the Site boundary.
- Provide for the continued control of potential off-site migration of contaminated groundwater to a level that is protective of surface water quality.
- Implement reasonable efforts to eliminate or mitigate further releases of contaminants from Site SWMUs (using the site boundary as the point of compliance).

The enhanced system would add more certainty and redundancy to total containment as measured at the POC.

6.4.7.3 REDUCTION OF TOXICITY, MOBILITY OR VOLUME (Moderate – 1)

- P&T systems are effective in reducing the concentration and volume and controlling the mobility of COIs in the groundwater.
- P&T systems over time will reduce the mass of the COIs on the Site by treatment of the groundwater containing the COIs.
- No immediate reduction of the sources of COIs.

6.4.7.4 SHORT-TERM EFFECTIVENESS (EFFECTIVE – 2)

- Meets the short-term CAOs Site groundwater.
- Prevent unacceptable human exposures to recovered contaminated groundwater.
- Maintain current groundwater recovery well system operation for groundwater collection and plume hydraulic containment within the Site boundary.
- Provide for the continued control of potential off-site migration of contaminated groundwater to a level that is protective of surface water quality.

6.4.7.5 IMPLEMENTABILITY (Easy – 2)

- On-site recovery well system has been in operation since 1985, operating continuously without interruption.
- The two additional groundwater recovery well locations can be selected and installed within operational constraints.
- The Bayer waste treatment facility has the capacity to treat the additional 300 gpm of groundwater.

6.4.7.6 COSTS (Moderate – 1)

New capital cost is estimated at $0.137 MM. O&M is about $0.500 MM per year. The engineering cost estimate summary is presented in **Table 6.4-4**.

6.4.7.7 COMMUNITY ACCEPTANCE (High – 2)

- No concerns are expected.

6.4.7.8 STATE ACCEPTANCE (High –2)

- No concerns with State/Agency acceptance are expected.

6.4.7.9 SITE-WIDE GROUNDWATER - ENHANCED SITE-WIDE GROUNDWATER CONTAINMENT AND TREATMENT – EVALUATION SUMMARY

Site-Wide Groundwater- Enhanced Site-wide Groundwater Containment and Treatment	Long-term Effectiveness	Reduction of Toxicity, Mobility and Volume	Short-term Effectiveness	Implementability	Costs	Community Acceptance	State Acceptance	Overall Numerical Ranking	Selected for SWMU or SWMU Group
	Effective 2	Moderate 1	Effective 2	Easy 2	Moderate 1	High 2	High 2	**12**	**Yes**

6.4.8 Corrective Measures Alternative Ranking Summary – Site-Wide Groundwater

Site-Wide Groundwater - Technology Evaluation Results Summary	
Technology	***Evaluation Result***
Institutional Controls	**Retained**
Covers/Caps (Soil, pavement and/or synthetic membranes)	
Containment Barriers (slurry wall)	X
Passive Treatment Walls [Vertical walls constructed by trenching and/or injection.]	
Zero-valent iron (ZVI)	
Biosparging	
In-Situ Treatment	
In-situ Chemical Oxidation (ISCO)	
In-situ Biological (ISB) [Aerobic and/or Anaerobic]	X
Chemical Flushing	
Soil Vapor Extraction (SVE)	
Enhanced SVE (In-situ thermal desorption by resistance and/or RF heating)	
Stabilization	
Ex Situ Treatment/Disposal [Assumes removal by excavation and/or pumping]	
On-site Incineration (Bayer Facility)	
Off-site Incineration	
Thermal Desorption	
Biopiles / Landfarming	
Soil Washing	
Off-site Landfill	
Groundwater Treatment	
Enhanced Site-wide Groundwater Containment and Treatment	**Retained**
Natural Attenuation	
Trenches and/or recovery wells – Perched water Collection	

X – ***Evaluated and eliminated from further consideration***

As indicated previously each of the potential Corrective Action technology alternatives for Site-wide Groundwater were ranked following the completion of the criteria evaluations. **Table 6.4-5** presents a summary of the non-discounted direct/indirect capital costs, O&M (annual) costs, and associated periodic costs for each of the evaluated Corrective Action technologies for comparative purposes. Present value calculations were completed for each of the individual Corrective Action technologies with the key assumption that the given technology was the only remediation required. **Table 6.4-6** presents a summary of the present value calculations for the evaluated Corrective Action technologies for Site-wide Groundwater. The retained Corrective

Action technologies will be utilized to formulate Site Corrective Measures Alternatives and discussed in Section 7.0.

7.0 RECOMMENDED SITE CORRECTIVE MEASURES

Potential Corrective Action technologies meeting threshold screening criteria in **Section 5.0** were evaluated in **Section 6.0** pursuant to the seven balancing criteria to further screen the list of technologies to those most appropriate for SWMU Group A, Main Plant Area (MPA) SWMUs and Site-wide Groundwater (see table below). Section 6.0 retained technologies have been grouped into combinations to form Site Corrective Measures Alternatives. The Site Corrective Measures Alternatives have been evaluated and the best-balanced Site Corrective Measures Alternative recommended. The rationale for the recommended Corrective Measures Alternative is discussed pursuant to attainment of Site CAOs and media specific clean-up goals (see **Sections 4.0** & **4.1** respectively); its relationship to the balancing criterion and statutory requirements vs. other alternatives; and consistency with RCRA Guidance and relevant Corrective Action precedent.

Section 6.0 Retained Corrective Action Technologies	
SWMU Group A	Institutional Controls
	Caps/Covers
	Perched water trench
	Slurry Wall Containment Barrier
Main Plant Area	Institutional Controls
	Caps / Covers - SWMU 27
	ISCO TTD - SWMU Groups C & D and SWMUs 21 & 27 (TEST SWMU 27)
	ISB TTD - SWMU Groups C & D and SWMUs 21 & 27 (TEST SWMU 27)
	On-Site Incineration -SWMU 27
	Off-Site Incineration - SWMUs 21/27
	Off-Site Landfill - SWMUs 21, 27
Site-wide Groundwater	Enhanced Site-wide Groundwater Containment and Treatment
	Institutional Controls

NOTES

TTD - Tiered Technology Demonstration

There are twenty to more than forty combinations that could be derived from the list of retained technologies for Site Corrective Measures Alternatives, dependent on how Institutional Controls are treated. The Site Corrective Measures Alternatives defined below represent only six technology combinations, from which a recommended Site Corrective Measure is to be made. There are other combinations possible, but these were selected to represent a broad range for each Site Area (i.e. SWMU Group A, MPA and Site-wide Groundwater) for comparative purposes. The comparative analysis of the Site Corrective Measures alternatives, rather than the specific groupings of technologies making up each alternative, represents the primary value of this section.

Table 7.0-1 presents a summary spreadsheet of the technology arrays for the following alternatives and may be a useful guide for Section 7 review.

Site Corrective Measures Alternative #1

- SWMU Group A – Institutional Controls (ICs), Cap (RCRA) and perched water collection trench;
- MPA SWMUs - Institutional Controls (ICs);
- Site-wide Groundwater - Institutional Controls (ICs) and Enhanced Site-wide Groundwater Containment and Treatment.

- **Site Corrective Measures Alternative #2**
  - SWMU Group A – Institutional Controls (ICs), Cap (Soil) and perched water collection trench;
  - MPA SWMUs - Institutional Controls (ICs);
  - Site-wide Groundwater – Institutional Controls (ICs) and Enhanced Site-wide Groundwater Containment and Treatment.
- **Site Corrective Measures Alternative #3**
  - SWMU Group A – Institutional Controls (ICs), Cap (Soil) and perched water collection trench
  - MPA SWMUs – Institutional Controls (ICs) and TTD for ISCO & ISB (SWMU Groups C & D and SWMUs 21 & 27)
  - Site-Wide Groundwater – Institutional Controls (ICs) and Enhanced Site-wide Groundwater Containment and Treatment.
- **Site Corrective Measures Alternative #4**
  - SWMU Group A – Institutional Controls (ICs), Cap (RCRA) and Slurry Wall Containment Barrier
  - MPA SWMUs – Institutional Controls (ICs) and Tiered Technology Demonstration (TTD) for ISB / ISCO (SWMU Groups C & D and SWMUs 21 & 27)
  - Site-Wide Groundwater – Institutional Controls (ICs) and Enhanced Site-wide Groundwater Containment and Treatment
- **Site Corrective Measures Alternative #5**
  - SWMU Group A – Institutional Controls (ICs), Cap (RCRA) and Slurry Wall Containment Barrier

- o MPA SWMUs – Institutional Controls (ICs) and Off site incineration or landfill for SWMUs 21 & 27; Tiered Technology Demonstration (TTD) for ISB / ISCO (SWMU Groups C & D)
- o Site-Wide Groundwater – Institutional Controls (ICs) and Enhanced Site-wide Groundwater Containment and Treatment

- **Site Corrective Measures Alternative #6**
  - o SWMU Group A – Institutional Controls ICs, Cap (Soil) and Slurry Wall Containment Barrier
  - o MPA SWMUs - Institutional Controls ICs and Off site incineration or landfill for SWMUs 21 & 27; Tiered Technology Demonstration (TTD) for ISB / ISCO (SWMU Groups C & D)
  - o Site-Wide Groundwater - Institutional Controls (ICs) and Enhanced Site-wide Groundwater Containment and Treatment

7.1 DESCRIPTION OF SITE CORRECTIVE MEASURES ALTERNATIVES

The technologies comprising each Site Corrective Measures Alternative have been thoroughly reviewed in previous sections of the CMS. Following are listings and brief summaries only of the technologies employed by each alternative for each of the Site areas.

7.1.1 SITE CORRECTIVE MEASURES ALTERNATIVE #1

- o SWMU Group A – Institutional Controls (ICs), Cap (RCRA) and perched water collection trench;
- o MPA SWMUs - Institutional Controls (ICs);
- o Site-wide Groundwater - Institutional Controls (ICs) and Enhanced Site-wide Groundwater Containment and Treatment

Alternative 1 consists of a RCRA-compliant landfill cap over SWMU Group A in combination with a perched water collection drain, as well as an Enhanced Site-wide Groundwater Containment and Treatment System and Institutional Controls (ICs) for the MPA SWMUs. Major components of Alternative #1 include the following:

- **SWMU Group A**
  - o Ash lagoon backfill to achieve sloped subgrade (min. 2%) , approximately 2,000 cy
  - o Site grading and subgrade fill to achieve min. 2% grade (avg. 1 ft thick over 7 acres- 11,000 cy)
  - o RCRA-compliant landfill cap- geotextile subbase, HDPE membrane (80 mil thick), geosynthetic drainage net, final cover soil (2 ft thick) and vegetation,

- Interceptor collection trench installed to approximately 620 ft-msl around the west, south and east perimeter of SWMU Group A, approximately 1600 linear ft. The trench includes a perforated HDPE pipe and coarse aggregate to a minimum of 10 feet depth, with five (5) collection sumps with submersible pumps that discharge to a central lift station for conveyance to the on-site wastewater treatment system. Average flow from the system is estimated to be approximately 4 gpm.

- **MPA SWMUs** - ICs including:
  - Plant safety plan with descriptions of SWMU and contaminants and safety protocols and restrictions for working within or near the SWMUs,
  - Hazard communication plan for worker activities potentially exposed to SWMU waste constituents, including periodic worker and contractor training as necessary, with a general plant facility plan and mapping notations for SWMU conditions for reference purposes,
  - Written procedure for handling contaminated soil.
  - Land Use Deed restrictions that run with the land and/or recordation with Miss Utility of West Virginia.
- **Site-wide Groundwater** – The Enhanced Site-wide Groundwater Containment and Treatment system is composed of:
  - ICs including local / state restrictions on well drilling and water use on Site; covenants running with the Site deed restricting groundwater drilling and use; enforceable conditions in the Site RCRA Corrective Action Permit preventing the use of groundwater except for approved purposes.
  - Optimized groundwater recovery system. For cost evaluation purposes, the enhanced system is assumed to consist of the three (3) current recovery wells and two additional recovery wells to further assure groundwater containment site-wide, assumed to recovery an estimated additional 300 gpm. The assumed new pumping rate is an increase of 70% from the current rate of 474gpm to an estimated 774 gpm. The actual design of the enhanced groundwater recovery system will be defined by an effectiveness modeling study to optimize the pumping scheme. Variables to be evaluated include pumping rate and well locations, including relocating the current three pumping wells.
  - Treatment of all recovered groundwater in the Bayer on-site biological wastewater treatment plant. The assumed final recovery rate of the Enhanced Site-wide Groundwater Containment and Treatment system for cost evaluation purposes is 774 GPM.

- o Additional monitoring wells in the alluvial aquifer. For cost evaluation purposes, the number of additional monitoring wells is assumed to be four (4). The actual number and location of monitoring wells for the Enhanced Site-wide Groundwater Containment and Treatment system will be addressed in the effectiveness modeling study.

These technology components have been described in more detail in Section 6.0.

7.1.2 SITE CORRECTIVE MEASURES ALTERNATIVE #2

Corrective Measures Alternative 2 differs from Alternative 1 in SWMU Group A only by replacement of the RCRA cap with a "Soil cap" over SWMU Group A. Alternative 2 consists of:

- o SWMU Group A – ICs, Cap (***Soil***) and perched water collection trench
- o MPA SWMUs - ICs;
- o Site-wide Groundwater – ICs and Enhanced Site-wide Groundwater Containment and Treatment

The cap for SWMU Group A analyzed in Section 6.0 was a RCRA cap that included a synthetic membrane (80-mil HDPE). The differences between Soil and RCRA capping technology are considered minor, and include long-term effectiveness and cost. The soil cap would consist of a fine-grained clayey soil compacted to achieve a low permeability barrier. The net infiltration into the underlying SWMU for the soil cap is expected to be slightly greater than a RCRA synthetic membrane cap. However, the difference with respect to leaching of SWMU constituents and effects on the alluvial aquifer are expected to be minor. An estimate of net annual leakage through each of the cap types from rainfall infiltration can be prepared using the EPA HELP Model. For the Site, the annual percolation rate for each of the cap types is estimated as follows:

Cap Type	Annual Rainfall, in.	Net Infiltration, in.	Cap Percolation, in.
Soil (K < $1x10^{-6}$ cm/sec)	44	12	0.5
RCRA with HDPE	44	12	0.1

If differential settling were to occur, the long-term effectiveness of the soil cap may be less than a RCRA cap that includes a synthetic membrane. After more than 20 years of settling however, the potential for differential settling is assessed to be low. Additional settlement could occur from waste consolidation and to a lesser degree, organic degradation. Underlying settlement could potentially affect cap geodrain failures and secondary permeability increases in the low permeability soil layer, thus increasing cap percolation over the long-term. A synthetic membrane could be less affected by differential settlement because of its material tensile strength and elongation properties. This effect, should it occur, is expected to be minor with respect to its affect on leaching of SWMU constituents to the alluvial aquifer.

7.1.3 SITE CORRECTIVE MEASURES ALTERNATIVE #3

Alternative 3 adds ISB Tiered Technology Demonstrations (TTD) for MPA SWMUs to Alternative 2. Alternative 3 consists of:

- SWMU Group A – ICs, Cap (Soil) and perched water collection trench
- MPA SWMUs – ICs and TTD for ISB and / or ISCO (SWMU Groups C & D and SWMUs 21 & 27)
- Site-Wide Groundwater – ICs and Enhanced Site-wide Groundwater Containment and Treatment

The ISB / ISCO TTDs would include:

- ✓ Up to five (5) demonstration test areas in the MPA conducted over a total 5 to10-year period,
- ✓ Each test area would involve either an ISCO or ISB pilot test, nominal 10,000 ft^2 area, in selected SWMU areas throughout the MPA that are most practically representative of SWMU conditions. The proposed test areas include SWMU 27, SWMU 21 and up to (3) other SWMU "hot spots".
- ✓ Future full-scale ISCO or ISB applications in the MPA will be based on the results of the TTDs.

The tiered technology demonstration (TTD) program will involve tests at selected SWMU areas in the MPA that are most representative of Site conditions. Implementation of the TTD program will provide site-specific data on the feasibility of ISCO and ISB pursuant to the MPA COIs and design data for estimating oxidant and/or biosupplement suitability, optimum dosage rates, application methods, and monitoring protocols.

The TTDs will be designed to be pilot-scale, in-situ tests for either ISCO or ISB within the MPA SWMUs. If the TTDs are shown to be successful, the full-scale application of either ISCO or ISB would be implemented on a selective SWMU basis (excluding SWMU Group B), depending on practical considerations in the plant operating areas as described in Section 6.0. Full-scale application of ISCO and/or ISB technologies would be expected to effect significant reductions in SWMU constituent levels and mass loading to the Alluvial Aquifer. These reductions would result in an acceleration of long-term improvements in Alluvial Aquifer water quality. Quantification and predictions of aquifer water quality improvements would be assessed after completion of the TTD testing.

Compared to Alternatives 1 and 2, successful demonstration and implementation of ISB and/or ISCO as source treatments for MPA SWMUs would potentially result in faster reduction of COI concentrations in Site groundwater.

7.1.4 SITE CORRECTIVE MEASURES ALTERNATIVE #4

Alternative 4 adds a SWMU Group A Slurry wall Containment Barrier to Alternative 3 and eliminates the SWMU Group A perched water collection trench. Alternative 4 consists of:

- SWMU Group A – ICs, Cap (RCRA) and Slurry Wall Containment Barrier
- MPA SWMUs – ICs and TTD for ISB and / or ISCO (SWMU Groups C & D and SWMUs 21 & 27)
- Site- wide Groundwater - ICs and Enhanced Site-wide Groundwater Containment and Treatment

As described in more detail in Section 6, for evaluation purposes, the soil-bentonite slurry wall is assumed to be installed to the bottom of the alluvial aquifer (~50-60 ft-bgs to bedrock) around the entire perimeter (~ 2500 LF) of SWMU Group A. The area within SWMU Group A requiring the slurry wall barrier covers approximately 7-acres and extends approximately 2500 lineal ft.

7.1.5 SITE CORRECTIVE MEASURES ALTERNATIVE # 5

Alternatives 5 and 6 differ from Alternatives 3 & 4 by using excavation and removal of MPA SWMUs 21 & 27 vs. ISCO and/or ISB TTDs. Alternative 5 consists of:

- SWMU Group A – ICs, Cap (RCRA) and Slurry Wall Containment Barrier
- MPA SWMUs – ICs; Off site incineration or landfill for SWMUs 21 & 27; and ISB and / or ISCO (SWMU Groups C & D).
- Site-wide Groundwater - ICs and Enhanced Site-wide Groundwater Containment and Treatment

Alternative 5 differs from Alternative 4 in the MPA only, where SWMUs 21/27 are removed and disposed of off-site either by incineration or at a landfill.

7.1.6 SITE CORRECTIVE MEASURES ALTERNATIVE # 6

Alternative 6 differs from Alternative 5 in SWMU Group A only, where the RCRA cap is replaced with a soil cap. Alternative 6 consists of:

- SWMU Group A – ICs, Cap (Soil) and Slurry Wall Containment Barrier.
- MPA SWMUs – ICs; Off-site incineration or landfill for SWMUs 21 & 27; and ISB and / or ISCO (SWMU Groups C & D).
- Site-wide Groundwater – ICs and Enhanced Site-wide Groundwater Containment and Treatment.

7.1.7 COMMON ELEMENTS AND DISTINGUISHING FEATURES OF EACH ALTERNATIVE

At sites where contaminants are left in place at levels that do not allow unrestricted use, Institutional Controls (ICs) to manage land use are used to ensure that the remaining COIs do not pose an unacceptable risk to human health or the environment. ICs consist of administrative, engineering and/or physical controls. Since wastes and COI affected soils and groundwater will continue to be managed in place long-term, ICs are included as an element of all alternatives, for all areas (i.e. SWMU Group A, MPA SWMUs and Site-wide Groundwater). The specific administrative, engineering and/or physical controls employed will differ somewhat, dependent on the final selected array of Corrective Measures.

All of the alternatives have the following additional common elements:

- Hydraulic containment of Site groundwater;
- Restoration of Site groundwater over time by extraction of the contaminated groundwater, treatment of the recovered water to remove the COIs, and the natural replacement of the affected groundwater with unaffected water via recharge and direct infiltration from precipitation;
- Cap/cover for SWMU Group A;
- Monitoring of Site groundwater to confirm containment at all times and restoration over time; and
- Monitoring of off-site drinking water wells to verify the absence of Site COIs and protection of human health

Alternatives 3 & 4 address SWMU sources via treatment, providing the potential for development and implementation of innovative, cost-effective technologies to accelerate restoration of Site-wide Groundwater beyond the rate being achieved with groundwater pump and treat technology alone.

Alternatives 4, 5 and 6 provide redundant, physical containment of SWMU Group A via installation of a slurry wall to bedrock in addition to site-wide hydraulic containment.

Alternatives 5 & 6 employ source removal to potentially enhance the rate of restoration of Site-wide Groundwater.

7.1.8 LONG-TERM RELIABILITY OF CORRECTIVE MEASURES ALTERNATIVES

The major technology included in all Site Corrective Measures Alternatives to ensure the continued protection of human health and the environment is hydraulic containment of groundwater by pumping and treating. This technology has been successfully and reliably implemented and demonstrated at the Site for over 20 years. Use of the Enhanced Site-wide Groundwater Containment and Treatment technology in all Site Corrective Measures Alternatives should be highly reliable as well.

The SWMU Group A RCRA Cap technology utilized in Alternatives 1, 4 & 5 as well as soil cap technology employed in Alternatives 2, 3 & 6 have been thoroughly designed and field tested in multiple situations. Reliability therefore is expected to be good for alternatives utilizing either of these technologies. The wastes associated with SWMU Group A have some unique characteristics which may create some settling issues to be dealt with in the cap design. If potential differential settling problems are manifested in SWMU Group A, the soil cap proposed in Alternatives 2, 3 & 6 will be somewhat more susceptible initially to those problems, but may be easier to repair and maintain if problems do occur. Both the RCRA and Soil Caps will require comparable levels of routine maintenance to ensure that adequate vegetation cover is established and maintained.

Alternatives 4, 5 and 6 employ a Slurry Wall Containment Barrier for SWMU Group A. Long term reliability for slurry walls in SWMU Group A would be expected to be reasonable based on the COIs that are known to be present.

Alternatives 5 & 6 employ excavation and removal for MPA SWMUs 21 & 27. This is not expected to affect the long term reliability for these alternatives.

Overall, Alternatives 1 & 2 would be expected to have good long-term reliability because they employ only technologies that have been successfully demonstrated long-term under site-specific conditions. Alternative 3 would be expected to exhibit high long-term reliability as well. Even though it introduces a new source control technology, the technology would be introduced in phases pursuant to successful long-term testing to demonstrate performance under site-specific conditions. Long-term reliability of Alternatives 4, 5 and 6 would be expected to be good but less than Alternatives 1, 2 & 3. This is based on the technical issues discussed earlier with installation and maintenance of the SWMU Group A slurry wall.

7.2 COMPARATIVE ANALYSIS OF ALTERNATIVES

This comparative analysis section discusses the seven balancing criterion and how well each Site Corrective Measures Alternative meets that criterion. The summaries below are summarized in a comparative format in **Table 7.3-3**.

7.2.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Overall protection of human health and the environment addresses the ability of an alternative to eliminate, reduce or control threats to public health or the environment through institutional controls, engineering controls, removal or treatment.

Alternatives 3, 4, 5 and 6 meet this criterion to an equal degree of effectiveness. Groundwater pumping and treating technology employed in all of the alternatives has been a primary tool in effectively and reliably protecting public health and the environment over the past twenty (20) years of operation. Alternatives 4, 5 and 6 provide redundant containment of SWMU Group A wastes via the slurry wall. However, all alternatives – based on the incorporation of additional levels of pumping compared to that which has been demonstrated to be effective at protecting public health and the environment over the past twenty (20) years – have redundant pumping capability – adding another layer of protection of public health and the environment.

Excavation and removal of potential sources of COIs from MPA SWMUs 21 & 27 pursuant to Alternatives 5 & 6 is not expected to significantly improve the ability of the Site to achieve this criterion.

Alternatives 1 and 2 also meet this criterion, although less effectively, since other alternatives will provide some additional MPA SWMU treatment of the sources via ISCO and/or ISB; and/or removal of sources via off-site incineration / landfill.

7.2.2 LONG TERM EFFECTIVENESS

Long-term effectiveness considers residual risk and the ability of an alternative to maintain protection of human health and the environment over time. This criterion includes consideration of residual risk following the implementation of Corrective Measures and the adequacy and reliability of controls.

Alternatives 3, 4, 5 & 6 provide the best long term effectiveness based on reduction of residual risk by increased pumping and reduced potential for infiltration of leaching medium in SWMU Group A wastes, coupled with utilization of ICs. Alternative 3 has demonstrated via the use of pump and treat technology over the past twenty (20) years the ability to reduce the mobility and volume of wastes and effectiveness in protecting human health and the environment over the long term.

7.2.3 REDUCTION OF TOXICITY, MOBILITY OR VOLUME

Reduction of toxicity, mobility or volume of waste considers the alternative's ability to reduce the harmful effects of COIs in the waste, the ability of the COIs to move in the environment and the amount of COIs present, including how the alternatives compare relative to EPA's expectation to use treatment as follows:

> "EPA expects to use treatment to address the principal threats posed by a site whenever practicable and cost effective. Contamination that represents principal threats for which treatment is most likely to be appropriate includes contamination that is highly toxic, highly mobile, or cannot be reliably contained, and that would present a significant to human health and the environment should exposure occur." (61 FR 19448)

This Site does not pose any "principal threats". That situation notwithstanding, as reflected in the RFI, all threats to human health and the environmental represented by the Site have been "reliably contained" (61 FR 19448), thus managing and reducing the <u>mobility</u> of Site COIs, for over 20 years - primarily as a result of the pumping and treatment of Site groundwater. In the 20 years of operation of the groundwater pump and treat system, an estimated 4.2 billion gallons of water have been extracted for treatment and 725,000 pounds of organic material have been removed from the alluvial aquifer. Therefore, pursuant to the CAO for groundwater requiring, "…reduction of contaminant levels, as practicable, over time to support reasonably expected use", there is evidence that the mobility and volume of COIs at the Site is being quantifiably reduced.

The fact that there has been an extended period of time at the Site during which, contaminant volumes are being reduced but without quantifiable reductions in Site COI concentrations in the leaching medium, parallels experiences at many other RCRA and CERCLA pump and treat sites. The concentration in the leaching medium is a function of several other variables characterizing the COIs in addition to the ``volume of the source. These variables include solubility and adsorption coefficients, partition gradients, equilibrium concentrations, contact time, etc. The current concentration levels of COIs in Site groundwater do not imply a failure of the pump & treat technology in place at the Site in reducing of toxicity, mobility or volume. Concentration levels of COIs in Site groundwater will decrease with continued containment and removal of COIs from the groundwater via implementation of the Enhanced Site-wide Groundwater Containment and Treatment system and reduction of sources via in-situ treatment.

Therefore, all alternatives are expected to be effective in reducing the volume and mobility of COIs through pumping of the groundwater and treatment ex-situ. Alternatives 5 & 6 reduce volume through removal of MPA SWMUs 21/27. However, Alternatives 3 & 4 employ the development of treatment technologies that have the potential to reduce mobility, volume and toxicity at an accelerated pace - through in-situ treatment. Alternatives 1 & 2 are effective in reducing volume but do not employ any technology for source reduction through treatment.

7.2.4 SHORT-TERM EFFECTIVENESS

Short-term effectiveness considers the length of time needed to implement a corrective measure and the risks to workers, residents and the environment during the implementation and operation until Site CAOs and media specific goals are achieved. Types of risks and factors to be considered include: fire, explosion, exposure to hazardous substances and potential threats associated with treatment, excavation, transportation and re-disposal or containment of waste material.

All alternatives will require some truck traffic through the community and the Site for the cover materials for SWMU Group A. Alternatives 1 & 2 would have minimal effect on the community and construction / plant workers because activities would be limited to a localized area of the Site. Alternative 3 would present no additional exposure potential to the community and minimal to plant and construction workers to implement the in-situ ISB and / or ISCO TTDs. Alternatives 5 and 6 would have maximum potential impact on the community based on additional truck traffic to transport the wastes from MPA SWMUs 21/27.

Alternatives 4, 5 and 6 would present the greatest potential for worker exposures because of the excavation, processing and re-injection of potentially contaminated soils from SMWU Group A (Slurry wall). Alternatives 5 and 6 would take the longest to implement (i.e. implement actions with potential for exposure).

Alternatives 1 & 2 have the shortest implementation time. Alternative 3 is equally short, excluding the long-term, low exposure potential period for implementation of the TTDs. Alternatives 4, 5 & 6 have the longest implementation time based on the requirement to build the SWMU Group A slurry wall and to remove wastes from MPA SWMUs 21/27.

The potential for environmental impacts during initial implementation are assessed to be essentially equivalent for all alternatives. Alternatives 3 & 4 have the potential to achieve the fastest rate of restoration of Site-wide groundwater – and thereby reduce in a more timely fashion any residual potential for environmental harm from offsite migration of contaminated groundwater – based on development of effective treatment technologies via the TTDs.

7.2.5 IMPLEMENTABILITY

Implementability addresses the technical and administrative feasibility of implementing the Corrective Measures from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other government entities are evaluated.

There are no anticipated insurmountable problems with availability of services and materials for any of the alternatives. All alternatives will incur equivalent levels of interactions with other government entities to develop, obtain approval and implement approved ICs. From a technical design and implementation standpoint, Alternatives 4, 5 & 6 are clearly the most difficult based on the slurry wall containment barrier for SWMU Group A; Alternatives 1 & 2 are the least; and Alternative 3 is slightly more difficult than 1 & 2 given the addition of the ISCO / ISB TTDs.

7.2.6 COSTS

Tables 7.2-1 through **7.2-6** present cost details for each Site Corrective Measures Alternative. **Table 7.2-7** presents a summary of those costs. Present value (PV) calculations were completed for each Site Corrective Measures Alternatives (See **Tables 7.2-8** through **7.2-13**). **Table 7.2-14** presents a summary of those present values.

Corrective Measures Alternatives PV costs range from $12 million for Alternative 2 to $22 Million for Alternative 5. The difference between Alternatives 1 & 2 is the type of cap on SWMU Group A; between 3 & 4 the type of cap and with / without slurry wall containment on SWMU Group A; and between 5 & 6 – the type of cap on SWMU Group A.

There is some uncertainty in the final costs for Alternates 3 & 4 based on the inclusion in these alternatives the development of ISCO / ISB Technologies. However, future decisions on the degree to which these source treatment technologies will be employed across the Site will be based on the cost effectiveness of these technologies vs. alternatives on-going at that time and their effectiveness in continuing to meet Site CAOs. Alternatives 4, 5 and 6 have a very high degree of uncertainty in PV based on the requirement to install a slurry wall in an operating site with significant underground unknowns (i.e. process lines, sewer lines, utilities, communications, and wastes) and surface complexities including close proximity to railways, the river and operating units.

7.2.7 Community Acceptance

As discussed in detail in Section 6.0, none of the individual technologies associated with the Site Corrective Measures Alternatives are expected to result in extreme concerns by the community. Effective communication of all alternatives and technologies employed will be critical in the approval process.

7.2.8 State Acceptance

As discuss in detail in Section 6.0, the State is familiar with and expected to be receptive to all proposed technologies incorporated in all alternatives. The viability of - and need for - alternative containment technologies for Site SWMUS, SWMU Group A in particular, is expected to be a concern. This anticipated concern has been addressed by this CMS.

7.3 RECOMMENDED SITE CORRECTIVE MEASURES ALTERNATIVES AND RATIONALE

Site Corrective Measures Alternatives technology arrays are presented graphically within **Table 7.3-1**.

Based on the evaluation results for the individual technologies and the combination of technologies represented by Site Corrective Measures Alternatives, the recommended Site Corrective Measure Alternative is as follows:

> **SITE CORRECTIVE MEASURES ALTERNATIVE #3** - SWMU Group A Cap (Soil), Main Plant SWMUs Tiered Technology Demonstrations and Site-Wide Alluvial Aquifer Recovery Wells and Onsite Treatment

7.3.1 CMS Criterion Evaluation

Balancing criterion for each alternative discussed in **Section 7.2** is summarized graphically in **Table 7.3-3**. The following conclusions can be drawn relative to recommended Alternative 3;

- Alternative 3 clearly meets all criterion and / or is a very effective alternative relative to all others;
- Alternatives 1, 5 and 6 do not meet all criterion and / or are clearly the least effective alternative for those criterion;
- Alternative 3 is the only alternative that “clearly meets” and / or is assessed to be “very effective alternative” or better – for all criterion.

As a result, Alternative 3 is assessed to be the best balanced Site Corrective Measures Alternative.

7.3.2 Achievement of Site CAOs and Media Specific Cleanup Goals

Both short and long-term CAOs for Site Soils focus on the protection of all potential human receptors from exposure to shallow and sub-surface soils. Corrective Measures Alternative 3 provides protection from potential human exposure via ICs (administrative and physical) and engineered soil cover for SWMU Group A.

Long-term Site CAOs for groundwater require:

(1) The prevention of unacceptable human exposure to contaminated groundwater. This approved CAO is stated as follows:

> Groundwater Cleanup criteria will require reasonable efforts to eliminate or mitigate further releases of contaminants from SWMUs (using the Site boundary as the point of compliance) …. These criteria may include the implementation of institutional or engineering controls.

(2) Actions to address further releases of contaminants to groundwater and reduction of COI levels in groundwater over time. This approved CAO is stated as follows:

> "Groundwater cleanup criteria will require …reduction of contaminant levels, as practicable, over time to support reasonably expected use. These criteria may include the implementation of instructional or engineering controls."

(3) Control of the migration of contaminated groundwater to a level that is protective of surface water. This approved CAO is stated as follows:

> "Surface water quality protection is defined as contamination levels that do not exceed WV Water Quality Standards applicable to the receiving stream (using the site boundary as the point of compliance)."

Alternative 3 will effectively attain the long-term groundwater CAOs as follows:

1. Human health will continue to be protected from contaminated groundwater via ICs to prevent potential exposure onsite and via hydraulic containment to prevent the potential for offsite migration. Hydraulic containment will be confirmed with periodic groundwater level measurements.
2. Actions to reduce contaminant levels, as practicable, over time to support reasonably expected use includes extracting the contaminated groundwater and removal of COIs via biological treatment. The development and implementation of ISB / ISCO site-specific treatment technologies has potential to significantly and cost effectively reduce MPA SWMU COI sources. Reduction of contaminant levels in groundwater will be confirmed via periodic measurements of COI concentration in groundwater and documentation of the volume (pounds) of COIs removed from the groundwater via biological treatment (from soils and/or groundwater).
3. Surface water will be protected from contaminated groundwater by hydraulic containment through the pumping of the alluvial aquifer and collection of perched water in SWMU Group A. Protection will be confirmed by periodic testing of groundwater at the POC and comparison to applicable WV Water Quality Standards.

7.3.3 Statutory Determination

The recommended Site Corrective Measures Alternative has been reviewed for consistency with statutory requirements related to Protection of Public Health and the Environment; the West Virginia Groundwater Protection Act; Cost Effectiveness; and Preference for Treatment as a Primary Element.

7.3.3.1 Protection of Human Health and the Environment

Remedies should be protective of human health and the environment, and maintain protection over time. Alternative 3 will protect human health and the environment through placement of a soil cover over SWMU Group A to prevent exposure through contact with surface and subsurface soils. The entire Site is under the control of Bayer and Institutional Controls developed and implemented by Bayer will prevent unacceptable exposures to Site workers, construction workers and other potential human exposures to shallow and subsurface soil contaminants associated with SWMU Group A and MPA SWMUs. Potential exposure to Site Groundwater and Site recovered groundwater will also be managed with Institutional Controls, including governmental controls such as zoning, ordinances, statutes and building permits; proprietary controls or legal instruments in the chain of title such as negative easements and covenants not to dig or drill; and enforcement tools such as enforceable permits.

The potential for any appreciable off-site migration that could create a potential exposure to Site contaminants to humans or the environment will be controlled by the Enhanced Site-wide Groundwater Containment and Treatment technology and verified on a continuing basis with the Site-wide and off-site monitoring program associated with Alternative 3.

7.3.3.2 West Virginia Groundwater Protection Act

The West Virginia Groundwater Protection Act is established by **W. Va. Code §22-12** et seq. ("**ACT**"). The Groundwater Protection Rule is established by **47CSR58** of the Legislative Rules ("**Rule**"). The Act in §22-12-4(b) requires the following pursuant to existing groundwater contamination:

> "Where the concentration of a certain constituent exceeds such standard (*defined as maximum contaminant levels permitted for groundwater as established by the Secretary*) due to human-induced contamination, no further contamination by that constituent is allowed and every reasonable effort shall be made to identify, remove or mitigate the source of such contamination and to strive where practical to reduce the level of contamination over time to support drinking water use".

The Rule in **§47-58-8 Remediation** states:

> 8.1 "The Division has the authority to order persons to conduct remedial actions…"
>
> (8.1.a) "The use of permanent solutions to the maximum extent practical to correct groundwater contaminations is preferred".
>
> (8.1.b) "Cleanup actions shall not rely primarily on dilution and dispersion of the substance if active remedial measures are technically and economically feasible, as determined by the Director".
>
> (8.1.c) "Adequate groundwater monitoring shall be conducted to demonstrate control and containment of the substance. The Director shall specify which parameters should

be monitored in a remedial operation. Groundwater monitoring must continue until results assure adequate remedial action was taken".

The recommended Corrective Measures Alternative will be in compliance with the West Virginia Groundwater Protection Act. As defined in detail in by this CMS, recommended Site-wide Corrective Measures represent "…reasonable efforts …" to identify, remove or mitigate the source of such contamination and to strive where practical to reduce the level of contamination over time to support drinking water use", as required by the Act. With respect to SWMU Group A where wastes remain in place below the saturated zone, "hydraulic containment can be accomplished by controlling the direction of groundwater flow with capture zones or pressure ridges or physical barriers."[4] Every reasonable effort will be made in the final hydraulic containment design for the Enhanced Site-wide Groundwater Containment and Treatment system to minimizing contact of uncontaminated groundwater with wastes in SWMU Group A, pursuant to the requirements of the Act [§22-12-4(b)]. One objective of the Enhanced Site-wide Groundwater Containment and Treatment design, with respect to SWMU Group A wastes, will be, "… to demonstrate control and containment of the substance", as required by the Rule (8.1.c).

7.3.3.3 Cost Effectiveness

EPA expects that Corrective Measures will be cost effective. In 61FR19448, EPA established its remedial expectations as follows: "Treatment should be used to address the principal threats posed by a site whenever practicable and cost-effective". Cost effectiveness is determined by comparing the cost of all alternatives being considered with their overall effectiveness to determine whether the costs are proportional with the effectiveness achieved. In making this determination, the following definition was used: "A remedy shall be cost effective if its costs are proportional to its overall effectiveness." ((NCP §300.430(f)(1)(ii)(D)). "Overall effectiveness" was assessed by evaluating the Site Corrective Measures Alternatives – all of which have satisfied RCRA threshold criterion (i.e. protective of human health and the environment; attains media clean-up objectives; and controls the sources[5]). This involved the assessment of the three (3) effectiveness related criterion of the seven balancing criterion in combination (Long-term effectiveness; reduction in toxicity, mobility or volume of wastes; and short-term effectiveness). Overall effectiveness was then compared to costs to determine cost-effectiveness (See **Table 7.3-2** and **Table 7.3-4**).

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[4] Pump and Treat Groundwater Remediation, A Guide for Decision Makers and Practitioners", EPA/625R-95/005, Section 5.1, Groundwater Barriers and Flow Control, page 28.

[5] "Control the source(s) of releases so as to reduce or eliminate, to the extent practicable, further releases of hazardous waste or hazardous constituents that may pose a threat to human health or the environment", **Handbook of Groundwater Protection and Clean-up Policies for RCRA Corrective Action**, EPA530-R-04-030, April 2004, page 4.1.

The pump & treat element of Alternative 3 has demonstrated reduction in toxicity, mobility or volume of wastes, equivalent to that which would be expected from Alternatives 4, 5 and 6. Alternatives 3, 4, 5 & 6 all have the potential for treatment of the wastes, given the TTDs in the MPA SWMUs. Alternative 3 has also demonstrated effectiveness in protecting human health and the environment over the long term, equivalent to that which would be expected from Alternatives 4, 5 and 6. Alternative 3 has much less short term risk than Alternative 4, 5 or 6. The estimated cost of Alternative 3 is much less than that of Alternative 4, 5 or 6. The relationship of overall effectiveness of Alternative 3 is therefore proportional to its costs and is deemed cost effective - representing a reasonable value for the money to be expended. Since Alternatives 4, 5 and 6 are estimated to be higher in cost and are equal or less effective alternatives, they are therefore not cost effective.

7.3.3.4 Preference for Treatment as a Primary Element

EPA expects to use treatment to address “principal threats” posed by a site whenever practicable and cost effective. Contamination that represents “principal threats” for which treatment is most likely to be appropriate includes contamination that is highly toxic, highly mobile, or cannot be reliably contained, and that would present a significant risk to human health and the environment should exposure occur (61FR III.A.4.b -19448). The Site does not represent any “principal threats”. Site contaminants have been contained successfully for over 20 years by the hydraulic containment system as demonstrated by periodic Site-wide monitoring of groundwater levels and gradients. However, Alternative 3 does employ a treatment technology development element (TTDs for ISCO and/or ISB) representing the potential to act as primary treatment for the reduction of sources of COIs which may contribute to groundwater contamination.

7.3.4 Consistency with Guidance

EPA’s regulatory provisions for Corrective Action at permitted facilities are found primarily in 40 CFR Part 264 Subpart F. However, EPA provides additional direction on Corrective Action through guidance, policy directives and related regulations. EPA’s **Handbook of Groundwater Protection and Clean-up Policies for RCRA Corrective Action**, EPA530-R-04-030, April 2004 (Handbook), is designed to assist regulators, members of the regulated community and the public in understanding EPA policies on protecting and cleaning up groundwater at RCRA Corrective Action facilities.

EPA’s overall groundwater protection and cleanup strategy for RCRA Corrective Action with respect to cleanup of contaminated groundwater is: “(1) prioritize cleanup activities to limit the risk to human health first; and then, (2) restore[6] currently used and reasonably expected

[6] “The term “restore” or “restoration” used in this context refers to achieving a certain cleanup level(s) developed to ensure protection based on maximum beneficial use of the groundwater at a particular facility. Restoring contaminated groundwater does not necessarily imply cleanup to pristine conditions”

sources of drinking water and groundwater closely hydraulically connected to surface waters, whenever such restorations are practicable and attainable (EPA, 1991b).” (Handbook, pg. 1.2).

The approved CAOs and selected Site Point-of-Compliance, as well as the proposed media specific goals for the Site, acknowledge the need for long-term containment of the plume. In long-term containment situations, EPA recommends actions “…controlling sources…as a means to demonstrate progress toward achieving the overall mandate to protect human health and the environment (Handbook, pg 4.2). “When containment is part of a final remedy, facilities and regulators should develop systems to monitor the effectiveness of the containment” (Handbook, page 4.5). Performance monitoring is designed to demonstrate whether or not a Corrective Measure is performing as expected.

Corrective Measures Alternative 3 meets the guidance pursuant to the Handbook for groundwater at a long-term containment site. Human health is protected and migration of the sources is controlled by the Enhanced Site-wide Groundwater Containment and Treatment system preventing the potential for off-site migration into drinking water sources and confirmed by site-wide POC performance monitoring, site-wide groundwater level monitoring / gradient determination and drinking water supply monitoring at off-site locations. The environment is protected by the Enhanced Site-wide Groundwater Containment and Treatment system by preventing the potential for contaminated groundwater from entering the nearby hydraulically connected Ohio River. Development of site-specific ISB and / or ISCO technology is the most cost-effective approach to define a treatment for the sources capable of accelerating the reduction of contaminant levels as “expected” by guidance.

7.3.5 CONSISTENCY WITH PRECEDENT

Thirty five (35) West Virginia RCRA Facilities in various stages of the Corrective Action process have been reviewed for comparison of Site recommended Corrective Measures with those taken at sites dealing with similar situations. None of the West Virginia sites have both environmental conditions comparable to Bayer and have selected final Corrective Measures that might inform the Bayer Corrective Measures selection process. While recognizing that states have primary responsibility for managing and protecting their groundwater resources, it may still be informative to compare Corrective Action at sites outside of West Virginia where similar environmental concerns have been addressed.

In a recent Region III action, EPA collaborated with Pennsylvania's Act 2 Land Recycling Program in achieving cleanup goals at the PECO facility in Chester. This facility was the former location of a resin manufacturing plant and hazardous waste recycler. The groundwater is contaminated by organic compounds and LNAPL, some of which discharged to adjacent surface water. The final remedy recognizes the technical limitations associated with groundwater restoration and establishes final cleanup goals for groundwater based on protection of surface water to which the plume discharges. The City of Chester code restricts people from using the groundwater as a source of drinking water. This use restriction is an important component of institutional controls to prevent exposure to groundwater contamination for the final remedy. http://www.epa.gov/reg3wcmd/ca/pa/pdf/pad000731026.pdf.

Actions taken at the PECO site have been assessed by EPA to be consistent with the EPA Handbook on groundwater cleanup. Several site physical features, environmental contamination and recommended protective approach parallels exist between the PECO facility in Chester, PA and the Bayer Site:

- Both are old industrial sites affording significant economic benefits to the local and regional communities;
- Both have VOC and SVOC contamination of groundwater that discharges via a long waterfront (2600 feet for PECO) to a major river;
- Cleanup goals acknowledge technical limitations and groundwater use at both sites, and focus on protection of surface water to which the plumes discharge;
- Both sites rely upon pump and treat as a primary technology and monitoring to contain the plume and protect the river;
- Both sites rely upon use restrictions as an important component of Institutional Controls.

Acknowledging that the State of West Virginia has primary responsibility for managing and protecting its groundwater resources, nevertheless, comparing the proposed actions for the Site to those developed at the PECO site indicates that the recommended Site Corrective Measures would lead to equivalent levels of protection that EPA would require if implementing the program.

7.4 PROPOSED CORRECTIVE MEASURES IMPLEMENTATION SCHEDULE

Following is a preliminary implementation schedule for recommended Site-Wide Corrective Measures:

- CMS submittal to Agencies – July 2006
- Agency approval of CMS – October 2006
- CMS Implementation Work Plan bid, evaluation and award – December 2006
- CMS Implementation Work Plan and approval – March 2007
- CMS Pre-Design Investigation Studies and Final Corrective Measures Design – December 2007
    - ✓ Groundwater Effectiveness Model design, approval and Implementation – July 2007
        - Enhanced Site-wide Groundwater Containment and Treatment Design and approval - December 2007
        - Performance Monitoring design and approval – December 2007

- ✓ SWMU Group A Perched Water Collection Trench design and approval – October 2007
- ✓ Tiered Technology Demonstration Design and approval – October 2007
- ✓ Institutional Controls Design and approval – October 2007

- Corrective Measures Implementation
  - ✓ SWMU Group A Implementation – January 2008 through September 2009
  - ✓ Institutional Controls Implementation – January 2008 through January 2009
  - ✓ MPA SWMUs Tiered Technology Demonstrations – January 2008 through 2013-2017
  - ✓ Enhanced Site-wide Groundwater Containment and Treatment – January 2008 – September 2009 and continuing.
  - ✓ Performance Monitoring – Installation January 2008 – April 2008. Begins May 2008 and continuing
- Corrective Measures Reporting
  - ✓ As approved

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FIGURES

TABLES

APPENDIX A

COST ESTIMATE DETAILS